Draft

Fish and Wildlife Coordination Act Report Appendix

Shasta Lake Water Resources Investigation, California

Prepared by:

U. S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region

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Fish and Wildlife Coordination Act Report Appendix

Introduction

The following Administrative Draft Coordination Act Report is included as part of the Fish and Wildlife Coordination Act (FCWA), as provided for in Section 2(b) of the FWCA (48 stat. 401, as amended). This Administrative Draft report is subject to change. The report assesses potential project effects on fish and wildlife resources and provides preliminary recommendations on how to avoid or minimize adverse effects. Reclamation has addressed many of U.S. Fish and Wildlife Service (USFWS) comments and will continue working to resolve additional comments on an ongoing basis. Reclamation is committed to continue working with the USFWS throughout the Shasta Lake Water Resources Investigation.

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United States Department of the Interior

Fish and Wildlife Service

Draft Fish and Wildlife Coordination Act Report

for the

SHASTA LAKE WATER RESOURCES INVESTIGATION

Prepared for:
U.S. BUREAU OF RECLAMATION
SACRAMENTO, CALIFORNIA

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EXECUTIVE SUMMARY

This document constitutes the U. S. Fish and Wildlife Service's (Service) Fish and Wildlife Coordination Act (FWCA) report to the U. S. Bureau of Reclamation (Reclamation) for the Shasta Lake Water Resources Investigation (SLWRI) (Project). The FWCA requires Federal agencies proposing water resource development projects or involved in issuance of related permits or licenses to consult with the Service and provide equal consideration to the conservation, rehabilitation, and enhancement of fish and wildlife resources with other project purposes. The findings of this report are based on information provided in the December 2006 and May 2007 Plan Formulation Report (PFR) (USBR 2006a, 2007a), available data, field investigations, and results of biological surveys (*e.g.*, North State Resources [NSR] 2004 and Lindstrand 2007). Our report addresses the proposed Project-related beneficial and adverse effects on fish and wildlife resources and provides recommendations for Project implementation.

Reclamation is the Federal lead agency for the SLWRI, pursuant to the National Environmental Policy Act (NEPA). In 2000, as a result of increases in demands for water supplies, and attention to ecosystem needs in the Central Valley of California, the Mid-Pacific Region of Reclamation reinitiated a feasibility-scope investigation to evaluate the potential of enlarging Shasta Dam. The SLWRI is being conducted under the general authority of Public Law 96-375 and the CALFED Bay-Delta Authorization Act, also known as Public Law 108-361. The SLWRI is designed to evaluate the feasibility of expanding the capacity of Shasta Reservoir for improved anadromous fish survival and improved water supply reliability, and to address other related resource needs in the primary and extended study areas.

The primary study area as defined in the SLWRI PFR (USBR 2007) includes the following areas (see Appendix A, Plate 1):

- Shasta Lake and tributaries (see Appendix A, Plate 2);
- Keswick Reservoir;
- Sacramento River between Keswick Dam and Red Bluff Diversion Dam (RBDD);
- Areas surrounding Shasta Lake that would be inundated by raising Shasta Dam (Inundation Zone).

The Service believes that the primary study area should be expanded to include areas above the Inundation Zone that would be impacted by dam construction activities and the relocation of campgrounds, marinas, roads, bridges, and other facilities. Additionally, the primary study area should be expanded to include the lower reaches of the tributaries to the Sacramento River between Keswick Dam and RBDD. These tributaries are important to the mainstem Sacramento River because of their significance in recruiting gravel and large woody debris, their importance for providing rearing habitat for salmonids (Maslin *et al.* 1996, 1997, 1998, 1999), and the potential for riparian restoration of the lower reaches of these tributaries within the SLWRI. Additionally, these tributaries may be affected by further downcutting and disconnection from the floodplain as a result of the reduction in flood flows in the mainstem Sacramento River with the proposed enlarging of Shasta Dam in the SLWRI.

The extended study area as defined in the SLWRI PFR (USBR 2007) includes the following areas:

- Sacramento River downstream from RBDD, including parts of the American River basin;
- Sacramento – San Joaquin Delta (Delta), including parts of the lower San Joaquin River;
- Water service areas of the Central Valley Project (CVP) and State Water Project (SWP) that may be affected by operational changes at Shasta Dam and Reservoir.

The Service believes that the extended study area should include not only the water service areas of the CVP and SWP, but also the areas downstream of CVP and SWP dams that could be affected by operational changes due to an enlarged Shasta Dam (*e.g.*, Oroville Dam and the lower Feather River; Folsom Dam and the lower American River) (see Appendix A, Plate 3). Additionally, the extended study area should include the CALFED water storage projects currently being evaluated for construction in the future (*e.g.*, Sites Reservoir, Los Vaqueros Reservoir, and Temperance Flat); likewise, the proposed raising of Shasta Dam should be included within planning for these future CALFED water storage projects.

The primary planning objectives for the SLWRI are increasing Water Supply Reliability and Anadromous Fish Survival. The secondary planning objectives for the SLWRI are Ecosystem Restoration, Flood Damage Reduction, Increased Hydropower Generation, and Recreation. Table 1 summarizes the primary and secondary planning objectives of the SLWRI and the resource management measures that were retained to address the planning objectives as currently defined in the May 2007 PFR (USBR 2007). However, many of the resource management measures that were "retained," including the three identified in Table 1, do not appear in the SLWRI alternatives as currently defined. The planning objectives were developed for the SLWRI based on identified water resources problems, needs, and opportunities, and information contained in the August 2000 CALFED Record of Decision (ROD). Resource management measures are features or activities that address a specific planning objective.

The SLWRI developed a No Action Alternative and five comprehensive alternative plans (CPs) based on comments received on the Initial Alternatives Information Report, input from the public scoping process, and continued coordination. The various CPs call for raising Shasta Dam 6.5, 12.5, or 18.5 feet and modifying the temperature control device (TCD) to improve delivery of cold water to anadromous fish spawning and rearing habitat. The CPs are as follows:

- CP1 – 6.5-Foot Dam Raise
- CP2 – 12.5-Foot Dam Raise
- CP3 – 18.5-Foot Dam Raise
- CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus
    - 378,000 acre-feet (af) dedicated for cold water storage to increase the volume of cold water available to the TCD

Table 1. Retained Measures to Address Planning Objectives

Planning Objective	Resources Management Measure	
	Title	Measure Description
Primary Planning Objectives		
Anadromous Fish Survival	* Restore Spawning Habitat	* Restore abandoned gravel mines along the Sacramento River
	Modify TCD	Make additional modifications to Shasta Dam for temperature control
	Enlarge Shasta Lake Cold Water Pool	Raise Shasta Dam to increase the cold water pool in the lake to benefit anadromous fish
	* Increase Minimum Flows	* Modify the storage and/or release operations of Shasta Dam and Reservoir to benefit anadromous fish
Water Supply Reliability	Increase Conservation Storage	Increase conservation storage space in Shasta Reservoir by raising Shasta Dam
	Reoperate Shasta Dam	Increase the effective conservation storage space in Shasta Reservoir by increasing the efficiency of reservoir operation for water supply reliability
	Perform Conjunctive Water Management	Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam
	Demand Reduction	Identify and implement, to the extent possible, water use efficiency methods
Secondary Planning Objectives		
Ecosystem Restoration	Restore Shoreline Aquatic Habitat	Construct shoreline fish habitat around Shasta Lake
	Restore Tributary Aquatic Habitat	Construct instream fish habitat on tributaries to Shasta Lake
	* Restore Riparian Habitat	* Restore riparian and floodplain habitat along the upper Sacramento River
Flood Damage Reduction	Modify Flood Management Operations	Update Shasta Dam and Reservoir flood management operations
	Increase Public Safety at Shasta Dam	Route PMF from top of conservation pool
Increased Hydropower Generation	Modify Hydropower Facilities	Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased head
Recreation	Restore and Upgrade Facilities	Restore and upgrade recreation facilities and opportunities
	Reoperate Reservoir	Increase recreation use by stabilizing early season filling in Shasta Lake

* Measures that do not appear in the SLWRI alternatives as currently defined.
Key: PMF = probable maximum flood; TCD = temperature control device
From the Shasta Lake Water Resources Investigation [SLWRI] Plan Formulation Report (USBR 2007).

- CP5 – 18.5-Foot Dam Raise, Combination Plan
    - Implement environmental restoration features along the lower reaches of major tributaries to Shasta Lake
    - Construct shoreline fish habitat around Shasta Lake
    - Constructing either additional or improved recreation features at various locations around Shasta Lake to increase the value of the recreational experience

In the CPs, as currently defined (USBR 2007), the only resource management measures that address the primary objective of Anadromous Fish Survival are enlarging the cold water pool and modifying the TCD in Shasta Lake to maintain cooler temperatures for anadromous fish spawning and rearing habitat in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam (RBDD). This reach of the Sacramento River is prime spawning habitat for anadromous fish [*e.g.*, Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), and green sturgeon (*Acipenser medirostris*)] and the only known spawning habitat for the federally endangered Central Valley winter-run Chinook salmon.

Only one alternative (CP4) provides *any* measurable benefit to anadromous fish survival, and even under that alternative, in the vast majority of years the enlarged cold water pool results in either negligible or slightly negative impacts to Chinook salmon survival. In about 90 percent of the years, there would be no benefit to anadromous fish survival. Even in CP4, the benefits of an enlarged cold water pool for each of the four runs of Chinook salmon are limited to a few critical and dry water years representing 6 – 16 percent of the water years, based on the 1922 – 2002 period of simulation. Simulations based on current Chinook salmon population levels (*i.e.*, 1999 – 2006 population average) and predicted higher future Chinook salmon population levels (*i.e.*, Anadromous Fish Restoration Program [AFRP] population goals) show that increases in immature smolt production of winter-, fall-, and late fall-run Chinook salmon relative to No Action in excess of 10 percent occurred in only 5 – 11 percent of the years simulated. Increases in spring-run Chinook salmon immature smolt production of greater than 10 percent occurred in 15 – 16 percent of the years simulated.

An analysis of the Salmod modeling results for the No Action alternative (Appendix B) reveals that thermal mortality to winter-, fall-, and late fall-run Chinook salmon is limited to 9 percent of the years simulated. Predominate sources of mortality were due to superimposition, habitat constraints, the flushing or dewatering of redds, and entrainment in unscreened diversions. Restoration opportunities that could assist in reducing these causes of mortality have been removed from further consideration, raising the prospect that those species could suffer further declines or, at a minimum, gain no benefit.

The restoration of spawning and rearing habitat, improving fish passage, increasing minimum flows, and screening water diversions would likely result in greater increases in anadromous fish survival during the 91 percent of the years when temperature is not a limiting factor as well as address the secondary objective of Ecosystem Restoration. In the CPs as currently defined (USBR 2007), the only resource management measure remaining that addresses the secondary objective of Ecosystem Restoration is unspecified restoration around Shasta Lake and tributaries in CP5.

The Service recommends that in order to address the primary objective of Anadromous Fish Survival and the secondary objective of Ecosystem Restoration, Reclamation should, beyond any actions identified and/or required in the Central Valley Project Improvement Act (CVPIA), CALFED, and existing biological opinions, incorporate into the SLWRI alternatives the following resource management measures that were initially considered but removed from further analysis:

- Restoring the riparian corridor along mainstem Sacramento River and the lower reach of nonnatal tributaries (see Sacramento River Conservation Area Forum [SRCAF] 2003; Riparian Habitat Joint Venture [RHJV] 2004; USFWS 2001, 2002, 2007a)

- Promoting Great Valley cottonwood regeneration along the Sacramento River

- Gravel augmentation in mainstem Sacramento River and lower reaches of tributaries.

- Increasing minimum flows in the upper Sacramento River from the current 3,250 cubic feet per second (cfs) to **4,000** cfs Oct 1 - Apr. 30, if end-of-September storage is 2.4 million af (MAF) or greater (per the AFRP Final Restoration Plan, USFWS 2001).

- Collaborating with the Anadromous Fish Screen Program to screen diversions and improve fish passage in mainstem Sacramento River and lower reach of nonnatal tributaries

- Restoring habitat at inactive gravel mines along the Sacramento River and lower reaches of tributaries

- Leaving the gates out at RBDD year-round

- Controlling invasive plant species along the Sacramento River and lower reaches of tributaries

Each of the resource management measures above is considered a high priority restoration goal by the AFRP (USFWS 2001), SRCAF (SRCAF 2003), California Partners in Flight (CalPIF) (CalPIF 2000, 2002a, 2002b, 2004), and/or RHJV (RHJV 2004). By including these instream, floodplain, and riparian restoration efforts in the SLWRI alternatives, the proposed project would be more likely to realize the primary and secondary planning objectives of Anadromous Fish Survival and Ecosystem Restoration. Additionally, by restoring a diversity of riparian successional stages along the Sacramento River, the SLWRI would have the added benefit of improving habitat for sensitive migratory bird species such as the bank swallow (*Riparia riparia*), black-headed grosbeak (*Pheucticus melanocephalus*), blue grosbeak (*Guiraca caerulea*), common yellowthroat (*Geothlypis trichas)*, song sparrow (*Melospiza melodia)*, Swainson's hawk (*Buteo swainsoni*), tree swallow (*Tachycineta bicolor*), tricolored blackbird (*Agelaius tricolor*), yellow-billed cuckoo (*Coccycus americanus*), yellow-breasted chat (*Icteria virens)*, and yellow warbler (*Dendroica petechia*) (RHJV 2004).

In addition to the above resource management measures, the Service has the following recommendations for the SLWRI alternatives (beyond any actions identified and/or required in CVPIA, CALFED, and existing biological opinions):

- Clarify whether and quantify the extent that the cold water pool (378,000 af) in CP4 would be used to augment flows to provide additional benefits for fish and wildlife species. Specify the authority for those augmented flows, and identify if those flows would be at the discretion of the Service; National Oceanic and Atmospheric Association, National Marine Fisheries Service (NOAA Fisheries); and California Department of Fish and Game (CDFG);

- Include monitoring and specific adaptive management measures in all SLWRI alternatives;
- Riprap removal along reaches of nonnatal tributaries and the mainstem of the Sacramento River supporting salmonid spawning and/or rearing habitat (USFWS 2004b);
- Increase water use efficiency to a specified level (*e.g.*, improve irrigation efficiency in the Anderson Cottonwood Irrigation District [ACID] canal);
- Ensure that Delta inflows for the Sacramento River and Yolo Bypass align with targets established in appropriate ongoing planning efforts and as provided in existing biological opinions.

Additionally, the Service believes that Reclamation should include a SLWRI alternative that evaluates the capability of increasing anadromous fish survival and water supply reliability without raising Shasta Dam. This could be accomplished by:

- Modifying the TCD at Shasta Dam to improve temperature control;
- Improving spawning habitat by gravel augmentation;
- Improving juvenile salmonid rearing habitat through large woody debris and riparian restoration (*i.e.* shaded riverine aquatic (SRA) cover) in the Keswick – RBDD reach, in the lower reaches of the nonnatal tributaries, and in the Sacramento River downstream from RBDD;
- Operational changes to Shasta Dam to increase cold water storage and/or increase minimum flows;
- Increasing water use efficiency to a specified level (*e.g.*, improve irrigation efficiency in the ACID canal);
- Considering conjunctive use of other existing and planned water storage facilities in the Central Valley.

Finally, the Service believes that the SLWRI could result in adverse affects to rare and special-status species in the vicinity of Shasta Lake, riparian habitat along the Sacramento River, and aquatic habitat in the Delta. It is unknown at this time if raising Shasta Lake would inundate a significant portion of the limited habitat of the following seven rare, but not federally listed, species each of which is endemic to the vicinity of Shasta Lake: Shasta snow-wreath (*Neviusia cliftonii*), Shasta salamander (*Hydromantes shastae*), Shasta sideband snail (*Monadenia troglodytes troglodytes*), Wintu sideband snail (*Monadenia troglodytes wintu*), Shasta chaparral snail (*Trilobopsis roperi*), Shasta hesperian snail (*Vespericola shasta*), and a rare undescribed variety of red huckleberry (*Vaccinium parviflorum*) but with blue berries unofficially known as

"Shasta huckleberry" (Lindstrand and Nelson 2005a,b; NSR 2004; Lindstrand 2007; DeWoody and Hipkins 2007; J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007). Additional habitat would be disturbed by construction-related activities and the relocation of campgrounds, roads, bridges, and other facilities above the Inundation Zone. The raising of Shasta Dam and implementation of the SLWRI would result in the loss, degradation, and fragmentation of habitat and may result in the need to further evaluate the factors threatening some of these seven species pursuant to section 4 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (ESA). Comprehensive effects analysis is not available, but partial information indicates the following:

- The rare terrestrial mollusks Shasta sideband snail and Wintu sideband snail are restricted to limited limestone outcrops in the vicinity of Shasta Lake; therefore, a portion of their habitat would be lost due to inundation or disturbance by the SLWRI.

- Shasta snow-wreath, in particular, could be adversely affected with 43 percent of all known occurrences of the plant species (9 out of 21 occurrences) being partly or completely inundated (Lindstrand and Nelson 2005a,b; Lindstrand 2007; CDFG 2007a). The CALFED Final Programmatic Environmental Impact Statement/ Environmental Impact Review (EIS/EIR) includes Shasta snow-wreath among "evaluated species for which direct mortality as a result of implementing CALFED actions is prohibited as a condition of the Multi-Species Conservation Strategy" (see Table 4-5 in Multi-Species Conservation Strategy section of CALFED 2000b).

- The CALFED Final Programmatic EIS/EIR and ROD (CALFED 2000a,b) also state that CALFED actions, such as the SLWRI, should maintain the status of and not threaten the population viability of the Shasta sideband snail and Shasta salamander.

The existing nesting habitat of the California rare western purple martin (*Progne subis arboricola*) behind Shasta Dam would be inundated by the SLWRI. In addition, four bald eagle (*Haliaeetus leucocephalus*) nests would be inundated with others likely disturbed by the SLWRI and would require consultation with the Service under the Bald and Golden Eagle Protection Act. The SLWRI could also inundate and disturb habitat of the Federal candidate species Pacific fisher (*Martes pennati pacifica*) and the federally threatened northern spotted owl (*Strix occidentalis caurina*). Riparian and floodplain habitat along the Sacramento River and in the Yolo and Sutter Bypasses would be adversely affected by further changes in the timing, duration, and frequency of flood flows due to an enlarged Shasta Dam. Raising the dam could also affect aquatic habitat in the Delta by potentially changing the location of the freshwater – saltwater mixing zone (X2), decreasing flushing flows, and increasing pumping at Tracy and Banks facilities during critical water years when more water may be available to pump as a result of the project.

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INTRODUCTION

In 2000, as a result of increases in demands for water supplies, and attention to ecosystem needs in the Central Valley of California, the Mid-Pacific Region of the U.S. Bureau of Reclamation (Reclamation) reinitiated a feasibility-scope investigation to evaluate the potential of enlarging Shasta Dam. The Shasta Lake Water Resources Investigation (SLWRI) is being conducted under the general authority of Public Law 96-375 and the CALFED Bay-Delta Authorization Act, also known as Public Law 108-361.

The Plan Formulation Report (PFR) (USBR 2007) identified two primary and four secondary planning objectives of the SLWRI (Table 1). The primary planning objectives are increasing Anadromous Fish Survival and Water Supply Reliability. The secondary planning objectives are Ecosystem Restoration, Flood Damage Reduction, Hydropower Generation, and Recreation. The Ecosystem Restoration objective includes restoring shoreline aquatic habitat around Shasta Lake, aquatic habitat for Shasta Lake tributaries, and riparian habitat for the upper Sacramento River and tributaries (between Red Bluff Diversion Dam (RBDD) and Keswick Dam).

The Draft Environmental Impact Statement/Environmental Impact Review (EIS/EIR) evaluates the future without Project condition (No Action Alternative) and five action alternatives (comprehensive plans [CPs]). The CPs raise the height of Shasta Dam 6.5 feet (CP1), 12.5 feet (CP2), or 18.5 feet (CP3, CP4, and CP5). CP3 focuses on both primary objectives of increasing anadromous fish survival and increasing water supply reliability. CP4 focuses on the primary objective of increasing anadromous fish survival by increasing the volume of cold water available to the temperature control device (TCD) through reservoir operations. CP5 addresses both primary objectives as well as the secondary objective of ecosystem restoration of shoreline and tributary fish habitat around Shasta Lake.

This document constitutes the U. S. Fish and Wildlife Service's (Service) Fish and Wildlife Coordination Act (FWCA) report to Reclamation regarding the proposed SLWRI project. It has been prepared under the authority of, and in accordance with, section 2(b) of the FWCA (Public Law 85-624; 16 U.S.C. 661-667e) and is for inclusion in the EIS/EIR for the SLWRI project. The FWCA requires Federal agencies to: 1) consult with the Service before undertaking or approving projects (carried out under Federal permits and licenses) that control or modify any bodies of water for any purpose; 2) provide equal consideration of fish and wildlife resources; and 3) coordinate fish and wildlife conservation with other project features.

Details of project effects on federally listed species and associated mitigation and compensation measures are being addressed in the associated SLWRI Action Specific Implementation Plan (ASIP). The ASIP identifies, evaluates, and discloses environmental impacts of the proposed action. It provides conservation measures to address the SLWRI regulatory requirements as presented in the CALFED Multi-Species Conservation Strategy (MSCS), programmatic biological opinions, and Natural Communities Conservation Plan determination. The section 7 consultations and biological opinions provided by the Service for the construction and operation of the facilities, will describe Reclamation's responsibilities pursuant to the Endangered Species Act (ESA).

BACKGROUND

Beginning in the late 1990s, Reclamation began assessing options for increasing water storage at Shasta Lake by raising the height of Shasta Dam (USBR 1998, 1999). In 2000, the CALFED Final Programmatic Record of Decision (ROD) (CALFED 2000a) identified an enlarged Shasta Lake as a means to increase the cold water pool available to maintain certain fisheries in the upper Sacramento River and to provide a more reliable water supply. That same year, Reclamation reinitiated a feasibility-level investigation to evaluate the potential for enlarging Shasta Dam—the SLWRI (USBR 2004a; 2004b).

In 2004, the following overall mission statement was defined for the SLWRI:

> *Mission Statement:* To develop an implementable plan primarily involving the enlargement of Shasta Dam and Lake to promote increased survival of anadromous fish populations in the upper Sacramento River; increased water supply reliability; and to the extent possible through meeting these objectives, include features to benefit other identified ecosystem, flood control, and water resources needs (USBR 2004a).

The SLWRI Environmental Scoping Report (USBR 2006d) lists two primary objectives for the SLWRI: (1) to increase the restoration of anadromous fish populations in the Sacramento River—primarily upstream from the RBDD, and (2) to increase water supplies and water supply reliability for agricultural, municipal, industrial and environmental purposes to help meet future water demands (with a focus on enlarging Shasta Dam and Lake). To the extent possible, the following secondary objectives would be met: (1) preserve and restore ecosystem resources in the Shasta Lake area and along the upper Sacramento River; (2) reduce flood damages along the Sacramento River; (3) develop additional hydropower capabilities at Shasta Dam; and (4) preserve outdoor recreation opportunities at Shasta Lake.

SLWRI planning principles have been framed such that "[P]rimary consideration should be given to recommendations in the CALFED ROD," and "[A]lternatives should be formulated to neither preclude nor enhance development and implementation of other elements of the CALFED program or other water resources programs and projects in the Central Valley." (USBR 2006a).

Related Programs and Legislation

Please see the Service's Planning Aid Memorandum dated February 16, 2007 (USFWS 2007a) which is attached in Appendix C of this report.

PROJECT SETTING

Project Area

The Plan Formulation Report (PFR) (USBR 2007) defines the primary study area for the SLWRI as Shasta Dam and Reservoir; the lower reaches of inflowing rivers and streams, including the Sacramento River, McCloud River, Pit River, and Squaw Creek; Keswick Dam and Reservoir; and the Sacramento River from Keswick Dam downstream to the RBDD. The RBDD was chosen as the downstream boundary of the primary study area because it is the point at which releases from Shasta Dam begin to have a negligible effect on Sacramento River water temperatures, and the river landscape changes to a broader, alluvial stream system (USBR 2007). For the purposes of this report, the Service includes within the primary study area the terrestrial and riparian areas surrounding Shasta Lake that would be directly or indirectly impacted by inundation, construction activities, or the relocation of facilities associated with the raising of Shasta Dam. The Service also includes within the primary study area the lower reaches of the tributaries to the Sacramento River between Keswick Dam and the RBDD that would be affected by a reduction in flood flows in the Sacramento River due to raising Shasta Dam.

Because of the potential influence of a modification of Shasta Dam on other resource programs and projects in the Central Valley, the extended study area primarily encompasses the following:

- Sacramento River downstream from the RBDD, including parts of the American River basin;
- Sacramento – San Joaquin Delta (Delta), including parts of the lower San Joaquin River;
- Water service areas of the Central Valley Project (CVP) and State Water Project (SWP) that may be affected by changes at Shasta Dam and Reservoir.

Maps of the primary study area, Shasta Reservoir area, and the major CVP and SWP facilities are included in Plates 1 – 3 in Appendix A of this report. The Service believes that the extended study area should include not only the water service areas of the CVP and SWP, but also the areas downstream of CVP and SWP dams that would be affected by operational changes due to an enlarged Shasta Dam (*e.g.*, Oroville Dam and the Feather River; Folsom Dam and the American River). Additionally, the extended study area should include the CALFED water storage projects currently being evaluated for construction in the near future (*e.g.*, Sites Reservoir, Los Vaqueros Reservoir, and Temperance Flat).

Shasta Dam and Reservoir (*i.e.*, Shasta Lake) are located on the upper Sacramento River in northern California, about 9 miles northwest of the City of Redding; the entire reservoir is within Shasta County. At gross pool, Shasta Reservoir stores 4.55 million acre-feet (af), covers an area of about 29,500 acres, and has a shoreline of about 400 miles. The reservoir controls runoff from about 6,420 square miles. The four major tributaries to Shasta Lake are the Sacramento River, McCloud River, Pit River, and Squaw Creek, in addition to numerous minor tributary creeks and streams.

PROJECT DESCRIPTION

<u>Alternatives</u>

The following summarizes the SLWRI alternatives as described in the PFR (USBR 2007). The CPs evaluate the primary objectives of increasing anadromous fish survival and water supply reliability by raising Shasta Dam 6.5 feet (CP1), 12.5 feet (CP2) or 18.5 feet (CP3, CP4, CP5). CP1, CP2, and CP3 focus on increasing water supply reliability while contributing to increased anadromous fish survival, actions which are consistent with the 2000 CALFED ROD. CP4 focuses on the primary objective of increasing anadromous fish survival. CP5 addresses both primary and secondary objectives including restoration of aquatic habitat around Shasta Lake shoreline and tributaries. The No Action Alternative evaluates the likely "future without project" conditions as required by the National Environmental Policy Act (NEPA). The No Action Alternative and the CPs are discussed in detail below.

No Action Alternative

Under NEPA, the No Action Alternative is defined as the "most likely future conditions" without the Project. In the PFR (USBR 2007), Reclamation defines the No Action Alternative as "the Federal Government would take no additional action to implement a specific plan to help increase anadromous fish survival in the upper Sacramento River, address, water supply reliability problems, needs, and opportunities in the Central Valley of California, or help restore ecosystem values, increase hydropower generation, or increase recreation opportunities at Shasta Lake." It is not clear to the Service whether this definition precludes management actions and operations without dam elevation. As discussed previously in the Service's Planning Aid Memorandum (see pp. 4-11, Appendix A; USFWS 2007a), certain actions for anadromous fisheries and associated habitats are already mandated by applicable regulations and policies (*e.g.*, Central Valley Project Improvement Act [CVPIA] and ESA). It should be clarified, within SLWRI analysis, which actions, goals and objectives are already the responsibility of the Federal Government in the extended planning area, and are thus to be expected to occur under the No Action scenario.

The Service believes the following activities are expected to take place, or should occur, with or without Shasta Lake expansion: (1) continued implementation of water use efficiency and conservation (*e.g.*, increased irrigation efficiency in the Anderson Cottonwood Irrigation District (ACID)), (2) Joint Point of Diversion exchanges between the CVP/SWP, (3) supply augmentation via land retirement (*e.g.*, the San Luis Drainage Feature Re-Evaluation [USBR 2006c]), (4) water transfers, (5) recycling, (6) Delta-Mendota Canal/California Aqueduct Intertie, and (7) Banks Pumping Plant expansion. These ongoing and anticipated projects should be included in modeling for all SLWRI alternatives, including No Action. To date within the SLWRI planning documents reviewed by the Service, it is not clear how or if these activities were considered in modeling efforts.

CP1 – 6.5 Foot Dam Raise

CP1 focuses on water supply reliability while contributing to anadromous fish survival. CP1 raises Shasta Dam 6.5 feet, an elevation change that increases the reservoir's gross pool by 8.5

feet, and enlarges the total storage space in the reservoir (and the total yield) by 256,000 af. Under this plan, Shasta Dam operational guidelines would continue unchanged, with the additional storage retained for increased water supply reliability during drought and average years. The increased pool depth and volume would also contribute to maintaining lower seasonal water temperatures for anadromous fish on the upper Sacramento River. At this time, however, it is not clear how the increased yield from the enlarged reservoir would be allocated.

CP2 – 12.5-Foot Dam Raise

As with CP1, CP2 focuses on water supply reliability while contributing to anadromous fish survival. CP2 raises Shasta Dam 12.5 feet, an elevation change that increases the reservoir's gross pool by 14.5 feet, and enlarges the total storage space in the reservoir (and the total yield) by 443,000 af. Like CP1, Shasta Dam operational guidelines would continue unchanged, with the additional storage retained for water supply reliability. The increased pool depth and volume would also contribute to maintaining lower seasonal water temperatures for anadromous fish on the upper Sacramento River. At this time, however, it is not clear how the increased yield from the enlarged reservoir would be allocated.

CP3 – 18.5-Foot Dam Raise

CP3 is similar to CP1 and CP2, but focuses on the greatest practical enlargement of Shasta Dam and Reservoir. CP3 raises Shasta Dam 18.5 feet, an elevation change that increases the reservoir's gross pool by 20.5 feet, and enlarges the total storage space in the reservoir (and the total yield) by 634,000 af to 5.19 million af. Like CP1 and CP2, Shasta Dam operational guidelines would continue unchanged, with the additional storage retained for water supply reliability. The increased pool depth and volume would also contribute to maintaining lower seasonal water temperatures for anadromous fish on the upper Sacramento River. At this time, however, it is not clear how the increased yield from the enlarged reservoir would be allocated.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus

The primary function of CP4 is to address anadromous fish survival, while still improving water supply reliability. It focuses on increasing the volume of cold water available to the TCD through reservoir operations, and on raising Shasta Dam by 18.5 feet. As with CP3, this raise would increase the reservoir's gross pool by 20.5 feet and enlarge the total storage space in the reservoir by 634,000 af to 5.19 million af. The PFR (USBR 2007) states, "This additional storage space would expand Shasta Lake's cold water supply available to the TCD by 378,000 af to help improve cooler water temperatures in the upper Sacramento River." However, it is not clear at this time whether the use of the 378,000 af (60 percent of increased storage) in CP4 is at the discretion of the resource agencies, or if the 378,000 af is solely for increasing the size of the cold water pool. It is our understanding that in current CALSIM hydrological modeling analysis for the SLWRI that CP4 is assumed to be the same as CP1 (6.5-ft dam raise alternative) with an increased yield of 256,000 af. The additional 378,000 af in CP4 is assumed to remain in storage in Shasta Lake to enlarge the cold water pool available to the TCD. At this time, however, it is not clear how the increased yield (and cold water storage) from the enlarged reservoir would be allocated.

CP5 – 18.5-Foot Dam Raise, Combination Plan

CP5 would address both the primary and secondary objectives. Like CP3 and CP4, CP5 includes enlarging Shasta Dam 18.5 feet. Like CP3, CP5 would have an increased yield of 634,000 af. CP5, however, also includes (1) implementing environmental restoration features along the lower reaches of major tributaries to Shasta Lake, (2) constructing shoreline fish habitat around Shasta Lake, and (3) constructing either additional or improved recreation features at various locations around Shasta Lake to increase the values of the recreational experience. At this time, the environmental restoration features and fish habitat construction associated with CP5 have not been identified.

Hydrological and Ecological Modeling

CALSIM II

On June 30, 2004, Reclamation's Central Valley Operations Office issued the Long-Term Central Valley Project CVP and SWP Operations Criteria and Plan (OCAP) Biological Assessment (BA) to update the proposed CVP operation in view of changes in regulations, increases in-system demand, and anticipated new programs/projects coming on-line in the future for ESA compliance. The National Oceanic Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries) and the Service issued their corresponding Biological Opinions in October 2004 and February 2005 (revision), respectively. The 2004 OCAP and OCAP BA were supported by a set of CALSIM II studies that were released by Reclamation on February 2, 2004, with revisions released on June 30, 2004 (USBR 2004c). Reclamation re-initiated ESA Section 7 consultation for OCAP with NOAA Fisheries and the Service in June and July 2006, respectively. Currently, Reclamation is in the process of developing a BA that would be used for the re-consultation. Since models for OCAP re-consultation are currently not available, the 2004 OCAP Study 3 and Study 5a were applied as the CALSIM II modeling bases in the SLWRI to ensure that modeling analyses were consistent with the most current CVP and SWP operating policy and planning standards. The 2004 OCAP Study 3 and Study 5a represent 2001 and 2020 levels of development for CVP/SWP system, respectively. Modifications were made on these two OCAP studies to represent each SRWRS modeling scenarios. The SLWRI uses the Common Assumptions Common Model Package Version 8D of CALSIM II.

CALSIM II simulates monthly flows throughout the CVP-SWP system based on climatic conditions during the October 1921– September 2003 simulation period. The main limitation of CALSIM II is the time-step. Mean monthly flows do not define daily variations that could occur in the rivers due to dynamic flow and climatic conditions. Therefore, CALSIM II masks any differences among the SLWRI alternatives that occur on a daily or weekly time scale such as changes in the duration and intensity of flood flows. In CALSIM II hydrological model simulations, CP4 is assumed to be the same as CP1 and CP5 is assumed to be the same as CP3 (USBR 2003).

Sacramento River Water Quality Model (SRWQM)

The Sacramento River Water Quality Model (SRWQM) utilizes the CALSIM monthly flows disaggregated into daily flows based loosely on historical patterns from 6-hour meteorological inputs developed for water years 1922 - 2002. The SRWQM outputs daily water temperatures. The disaggregation process, however, results in a very crude representation of flow and temperature conditions on a daily time scale (USBR 2003; R. Yaworsky, Reclamation, pers. comm., 2007). Reservoirs modeled by the SRWQM include Trinity, Lewiston, Whiskeytown, Shasta, and Keswick. River reaches modeled include the Sacramento River from Keswick Dam to Knights Landing and Clear Creek from Whiskeytown Dam to the confluence with the Sacramento River.

Salmod

Salmod simulates the effects of flow and temperature on salmon production and mortality for each of the four runs of Chinook salmon in 14 reaches of the Sacramento River between Keswick Dam and RBDD for water years 1922 - 2002. Salmod utilizes SRWQM daily flow and temperature output aggregated into weekly timesteps for the 81-year simulation period. Salmod presupposes egg and fish mortality are directly related to spatially and temporally variable microhabitat and macrohabitat limitations, which themselves are related to the timing and volume of streamflow and other meteorological variables. Salmod is a spatially explicit model in which habitat quality and carrying capacity are characterized by the hydraulic and thermal properties of individual mesohabitats, which serve as spatial computation units in the model. The model tracks a population of spatially distinct cohorts that originate as eggs and grow from one life stage to another as a function of water temperature in a computational unit. Individual cohorts either remain in the computational unit in which they emerged or move, in whole or in part, to nearby units. Model processes include spawning (with redd superimposition), incubation losses (from either redd scouring or dewatering), growth (including egg maturation), mortality due to water temperature and other causes, and movement (habitat- and seasonally induced).

Salmod differentiates between "base" mortality and "project-related" mortality. "Base", or background, rates of mortality cover all causes of death not otherwise modeled by Salmod. For example, "normal" or "background level" predation falls into this category, as would mortality due to chronically low dissolved oxygen egg survival, unscreened diversions, and the like. The fractional rates used came from the calibrated Trinity River model and are identical to those used previously on the Sacramento River (Bartholow 2003). The weekly base mortality rates were eggs, 0.035; fry, 0.025; pre-smolts, 0.025; and immature smolts, 0.025. The adult rate was 0.002 based on judgment. "Project-related" mortality is simulated for each life stage of Chinook salmon in Salmod based on unsuitable water temperatures (temp mortality), flushing flows or redd dewatering (incubation), spawning on top of a currently incubating redd (superimposition), and forced movement due to flows and/or fish density (habitat mortality). Note that the No Action Alternative can have "project-related" mortality (*i.e.*, temp, incubation, superimposition, and habitat) as defined above. Salmod also simulates mortality related to entrainment of salmonids in unscreened water diversions (seasonal mortality). The different types of mortality simulated by Salmod for each life stage are further defined below:

- <u>Pre-spawn base mortality</u>: number of eggs lost due to mortality of adult females before spawning due to factors that would occur regardless of the Project (*e.g.*, predation); pre-spawn base mortality is assigned a weekly mortality rate of 0.002.

- Pre-spawn project mortality: number of eggs lost *in vivo* (while eggs are still inside the female) due to Project-related temperature mortality prior to spawning.

- Incubation mortality: number of eggs lost due to flushing flows or redd dewatering resulting from Project-related actions (*i.e.*, above background levels).

- Superimposition: number of eggs lost due to spawning on top of a currently incubating redd resulting from Project-related activities.

- Eggs-base mortality: number of eggs lost due to factors that would occur regardless of the Project; in Salmod the weekly eggs-base mortality rate is assigned a value of 0.035.

- Eggs-temp mortality: number of eggs lost due to unsuitable water temperatures in which the exposure kills the egg after spawning.

- Fry-base mortality: number of fry lost due to factors that would occur regardless of the Project (*e.g.*, predation); in Salmod the weekly fry-base mortality rate is assigned a value of 0.025.

- Fry-temp mortality: number of fry lost due to unsuitable water temperatures.

- Fry-habitat mortality: number of fry lost due to Project-related mortality resulting from forced movement due to habitat constraints; this mortality is triggered by flow and fish density within the habitat.

- Pre-smolt-base mortality: number of pre-smolts lost due to factors that would occur regardless of the Project (*e.g.*, predation); in Salmod the weekly pre-smolt-base mortality rate is assigned a value of 0.025.

- Pre-smolt-temp mortality: number of pre-smolts lost due to unsuitable water temperatures.

- Pre-smolt-habitat mortality: number of pre-smolts lost due to Project-related mortality resulting from forced movement due to habitat constraints; this mortality is triggered by flow and fish density within the habitat.

- Pre-smolt seasonal mortality: extra outmigration mortality due to factors such as water diversions.

- Immature smolt-base mortality: number of immature smolts lost due to factors that would occur regardless of the Project (*e.g.*, predation); in Salmod the weekly immature smolt-base mortality rate is assigned a value of 0.025.

- Immature smolt-temp mortality: number of immature smolts lost due to unsuitable water temperatures.

- Immature smolt-habitat mortality: number of immature smolts lost due to Project-related mortality resulting from forced movement due to habitat constraints; this mortality is triggered by flow and fish density within the habitat.

- Immature smolt-seasonal mortality: extra outmigration mortality due to factors such as water diversions.

"Production" is defined by Salmod as the number of immature smolts that survive to outmigrate past the RBDD. In the case of fall-run Chinook salmon, tributary entrants (the number of young fall-run Chinook salmon entering the Project Reach from the tributaries) are included in the Salmod simulation and final production values. However, because Salmod is not able to simulate more than one Chinook salmon run at a time, the simulations of winter-, spring-, and late fall-run Chinook salmon do not include tributary entrants. Therefore, Salmod is not able to simulate the effects of resource competition and predation among the different size classes of the four runs of Chinook salmon (and the tributary entrants) and steelhead as they simultaneously inhabit the Sacramento River between Keswick Dam and RBDD. Competition and predation among the four runs of Chinook salmon and steelhead are thought to be an important source of mortality for salmonids in the Sacramento River (Koch *in litt.* 2006; B. Oppenheimer, NOAA Fisheries, pers. comm., 2007).

Salmod assumes a constant number of returning adult spawners; therefore, the cumulative effects of the SLWRI alternatives on the population of the four runs of Chinook salmon cannot be tracked through time. To analyze the effects of the SLWRI alternatives on current low population levels of Chinook salmon, the number of adult spawners returning every year in Salmod was based on the 1999 – 2006 population averages (California Department of Fish and Game [CDFG] 2007b). To analyze the effects of the SLWRI alternatives on predicted higher Chinook salmon populations in the future, the number of adult spawners returning every year in Salmod was based on the Anadromous Fish Restoration Program (AFRP) population goals.

Salmod simulations of Chinook salmon survival are limited to the reach of the Sacramento River between Keswick Dam and RBDD. Therefore, Salmod is not able to simulate juvenile mortality in the Sacramento River downstream from RBDD. Snorkeling surveys of juvenile Chinook salmon (Cannon 2007) suggest that the lack of suitable juvenile rearing habitat in the middle Sacramento River (*i.e.*, river miles 180 – 230 (a few miles downstream from Ord Ferry up to Elder Creek)) is likely the most limiting factor for Chinook salmon survival in the Sacramento River; only 1 percent of this reach of the middle Sacramento River is suitable rearing habitat for juvenile Chinook salmon (Cannon 2007). Thus the benefits of an increase in immature smolt production from an enlarged cold water pool in the SLWRI alternatives as shown in Salmod may be overshadowed by high mortality of juvenile Chinook salmon downstream from the RBDD. Salmod is also not able to simulate the effects of cover (*i.e.* shaded riverine aquatic (SRA) cover and large woody debris) on juvenile Chinook salmon survival. Thus, Salmod is not able to analyze the benefits of riparian habitat restoration along the Sacramento River.

Salmod neglects juvenile rearing in nonnatal tributaries; Maslin *et al.* (1996, 1997, 1998, 1999) found juvenile Chinook salmon rearing in the lower reaches of all 30 of the intermittent nonnatal tributaries of the Sacramento River surveyed. The warmer temperatures and pulses of organic matter in the intermittent tributaries resulted in faster growth rates of juvenile Chinook salmon.

Juvenile winter-run Chinook salmon in particular were found in disproportionate numbers over 3 km upstream in nonnatal tributaries. Faster growing fish smolt earlier, and may enter the Delta earlier in the year, before low water and pumping degrade rearing habitat. Optimal rearing conditions in the tributaries exist from about December through March (Maslin *et al.* 1999).

A discussion of the Salmod output and associated figures as it relates to sources of mortality for each of the four runs of Chinook salmon is provided in Appendix B of this report.

Project Construction Activities

There is not enough information at this time on construction activities associated with raising Shasta Dam and the relocation of roads, bridges, campgrounds, and other facilities. Since the locations and acreages needed for new facilities have not been yet developed, no impact analysis has been completed by the Service.

Conservation Measures

No conservation measures have been identified by Reclamation for the SLWRI. The Service has provided recommendations for conservation measures in the "Recommendations" section of this report. Also, conservation measures identified for MSCS species and habitats in the CALFED Programmatic documents are included in Appendix D of this report.

Alternatives and Measures Considered but Eliminated from Further Analysis

Initial Alternatives

In the initial development of alternatives, Reclamation considered alternatives that focused on the primary objective of Anadromous Fish Survival (AFS-1, AFS-2, and AFS-3) and the primary objective of Water Supply Reliability (WSR-1, WSR-2, WSR-3, and WSR-4) (USBR 2006a, 2007a). AFS-1, AFS-2, and AFS-3 were limited to a dam raise of 6.5-feet while WSR-1, WSR-2, and WSR-3 evaluated dam raises ranging from 6.5 feet to 202.5 feet. The AFS alternatives included the following resource management measures to address the primary objective of Anadromous Fish Survival and the secondary objective of Ecosystem Restoration: 1) enlarging the cold water pool, 2) increasing seasonal minimum flows, and 3) restoration of inactive gravel mines. Below is a summary of the AFS alternatives as described in the December 2006 SLWRI Plan Formulation Report (USBR 2006a).

Additional resource management measures were considered in the Plan Formulation Report to address Anadromous Fish Survival and Ecosystem Restoration, but were eliminated from further analysis. These resource management measures are discussed later in the section "Resource Management Measures Removed from Further Consideration."

AFS-1 Increase Cold Water Assets with Shasta Operating Pool Raise (6.5 Feet)

The major plan components of AFS-1 are:

- Raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the cold water pool and regulating water temperature in the upper Sacramento River

- Increasing the size of the minimum end-of-October operating pool to 880,000 af to allow additional cold water to be stored for use the following year

Both of the major plan components focus on increasing the volume of cold water in Shasta Lake available for regulating water temperature on the upper Sacramento River. AFS-1 would increase the capacity of the reservoir by 290,000 af to a total of 4.81 million af. The existing TCD would be extended and potentially modified. In addition, the minimum end-of-October carryover storage target would be increased from 1.9 million af to about 2.2 million af, increasing the minimum operating pool to 880,000 af. This would allow additional cold water to be stored for use the following year. No changes would be made to the existing seasonal temperature targets for anadromous fish on the upper Sacramento River, but the ability to meet these targets would be improved.

AFS-2 Increase Minimum Anadromous Fish Flow with Shasta Enlargement (6.5 Feet)

The major plan components of AFS-2 are:

- Raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the volume of water available to meet minimum flows for winter-run salmon on the upper Sacramento River

- Increasing seasonal minimum flows in the upper Sacramento River from the current 3,250 cubic feet per second (cfs) to about 4,200 cfs

Additional storage created by raising the dam would be focused on increasing the minimum flow target for winter-run Chinook salmon in the Sacramento River between Keswick and RBDD, consistent with the goals of the January 2001 Final Restoration Plan for the AFRP (USFWS 2001). Similar to AFS-1, this initial plan would increase the capacity of the reservoir by 290,000 af to a total of 4.81 million af, and extend the existing TCD to achieve efficient use of the expanded reservoir. AFS-2 differs from AFS-1 in that the additional storage would be used to increase minimum flows, rather than temperature, and no changes would be made to the carryover target volume or minimum operating pool.

Reclamation states that “AFS-2 would use the additional 290,000 af of storage in Shasta to increase minimum flows in this reach of the upper Sacramento River between October 1 and April 30” (Appendix A, p. A.4-6, USBR 2006a). The 1993 biological opinion for winter-run Chinook salmon (NOAA Fisheries 1993) required minimum flows of 3,250 cfs from October 1 through March 31 to protect rearing juveniles (*i.e.*, assist in downstream migration and help prevent stranding). The 2001 AFRP Final Restoration Plan (USFWS 2001) recommends minimum Sacramento River flows at Keswick Dam for October 1 to April 30 based on October 1 carryover storage in Shasta Reservoir and critically dry runoff conditions (driest decile runoff of 2.5 million af) to produce a target April 30 Shasta Reservoir storage of 3.0-3.2 million af for temperature control (Table 2).

Recommendations in the AFRP Final Restoration Plan (USFWS 2001) are based on maintaining sufficient carryover storage in Shasta Reservoir for temperature control for winter-run Chinook salmon. However, the winter-run Chinook salmon spawning period runs from late April – October with peak spawning in May – June (Table 7, CDFG 1998, Moyle 2002, Vogel and

Marine 1991). Therefore, the October 1 to April 30 time period for increasing minimum flows suggested in AFS-2 would not include the winter-run Chinook salmon spawning period. The recommendations and reasonable and prudent measures in the 1993 biological opinion (NOAA Fisheries 1993) and the AFRP Final Restoration Plan (USFWS 2001) were based on a limited cold water pool available in Shasta Reservoir. However, with improvements to the TCD and an enlarged cold water pool in Shasta Reservoir, increases in minimum flows could be provided in May – September as well to improve spawning habitat for endangered winter-run Chinook salmon while maintaining enough cold water storage for temperature control. If increasing minimum flows were combined with higher Shasta Dam raises (*e.g.*, 18 feet), then both flow and temperature requirements could be met for winter-run Chinook salmon.

AFS-3 Increase Minimum Anadromous Fish Flow and Restore Aquatic Habitat with Shasta Enlargement (6.5 Feet)

The major plan components of AFS-3 are:

- Raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the volume of water available to meet minimum flows for winter-run salmon on the upper Sacramento River

- Increasing seasonal minimum flows in the upper Sacramento River from the current 3,250 cfs to about 4,200 cfs

- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to restore about 150 acres of aquatic and floodplain habitat.

AFS-3 differs from AFS-2 in that an additional increment of instream habitat would be provided by gravel mine restoration along the upper Sacramento River. Restoration would involve filling deep pits, recontouring the stream channel and floodplain to mimic more natural topography, and reconnecting the reclaimed area to the Sacramento River. Side channels and other features would be created to encourage spawning and rearing, and restored floodplain lands would be revegetated using native riparian plants.

Table 2. Recommended minimum Sacramento River flows at Keswick Dam for October 1 to April 30 based on October 1 carryover storage in Shasta Reservoir (Final Restoration Plan for the AFRP, USFWS 2001)

Carryover Storage (million acre-feet)	Keswick Release (cfs)
1.9 to 2.1	3,250
2.2	3,500
2.3	3,750
2.4	4,000
2.5	4,250
2.6	4,500
2.7	4,750
2.8	5,000
2.9	5,250
3	5,500

Similar to AFS-2, Reclamation states that "AFS-3 would use the additional 290,000 af of storage in Shasta to increase minimum flows in this reach of the upper Sacramento River between October 1 and April 30" (Appendix A, p. A.4-7 and 4-8, USBR 2006a). However, as stated above, the winter-run Chinook salmon spawning period runs from late April – October with peak spawning in May – June (Table 7; CDFG 1998, Moyle 2002, Vogel and Marine 1991).

Reclamation further states that:

> *AFS-3 would support the primary planning objective of anadromous fish survival by increasing minimum flows from October 1 through April 30 and restoring 150 acres of aquatic and floodplain habitat at one or more inactive gravel mines on the upper Sacramento River. Together, it is estimated that the minimum flow increase and habitat restoration would add approximately 320 acres of potential spawning habitat to the upper Sacramento River between Keswick and Battle Creek (Appendix A, Chapter 4, pp. A.4-7 and A.4-8, December 2006, SLWRI Plan Formulation Report, USBR 2006a).*

The Service has not had the opportunity to evaluate the Salmod modeling for the initial alternatives AFS-2 and AFS-3. It is our understanding that the Salmod modeling has gone through several revisions; therefore, further analysis of the effects of increasing seasonal minimum flows is required.

The Service believes that Reclamation should evaluate other opportunities for increasing Anadromous Fish Survival and Ecosystem Restoration in the mainstem Sacramento River (Keswick Dam – RBDD), in adjacent tributaries, and in the Sacramento River further downstream. The section below discusses some of these resource management measures that were removed from further consideration but would address the primary and secondary goals of Anadromous Fish Survival and Ecosystem Restoration.

Initial Resource Management Measures

In the formulation of the initial and final alternatives, Reclamation considered the following resource management measures to address the primary objective of Anadromous Fish Survival and the secondary objective of Ecosystem Restoration.

Restoration of Abandoned Gravel Mines along the Sacramento River

One of the initial alternatives considered but removed from further analysis, AFS-3, contained the restoration of 150 acres of abandoned gravel mines along the Sacramento River. As of the March 2007 PFR (USBR 2007), the restoration of abandoned gravel mines continues to be a resource management measure retained for the primary planning objective of Anadromous Fish Survival (see Table 1). However, the restoration of abandoned gravel mines does not appear in any of the alternatives associated with the SLWRI as currently defined. Table 3 below summarizes the potential gravel mine restoration sites identified in the December 2006 PFR (USBR 2006a). Reclamation further stated in the December 2006 PFR:

> *Protecting and restoring spawning and rearing habitat have been identified by National Oceanic and Atmospheric Administration (NOAA) Fisheries as a*

primary goal in the recovery of Sacramento River winter-run Chinook salmon. It is estimated that over 80 percent of the winter and spring-run Chinook spawning population migrates to the upper Sacramento River when passage at the RBDD is unobstructed. Therefore, restoring suitable spawning habitat in the upstream reach of the river has potential to benefit a large portion of the salmonid population.

One method of increasing anadromous fish survival is rehabilitating lands formerly mined for gravel along the Sacramento River. Instream gravel mining degrades aquatic and floodplain habitat by (1) creating large artificial pits along the river that disrupt natural geomorphic processes and riparian regeneration, (2) stranding fish and encouraging predation, and (3) removing valuable gravel sources. Aquatic conditions at former gravel mining sites are typically unsuitable for spawning and rearing. High fish mortality occurs at many abandoned pits that effectively lose their connection with the river during low flow periods, stranding fish and encouraging unnatural predation rates. Due to changes in flow regime and reductions in coarse sediment input, the river is not capable of refilling and restoring many of these pits naturally. In addition, removing fine sediments during the gravel extraction process inhibits establishment of riparian vegetation that provides protective cover and shade for spawning and rearing.

Table 3. Potential Gravel Mine Restoration Sites along the Sacramento River

POTENTIAL GRAVEL MINE RESTORATION SITES ALONG THE SACRAMENTO RIVER

Location	Approximate River Mile	Bank	Area acres
Red Bluff near Salt Slough	247	Left	140
Upstream of Stillwater Creek	282	Right	320
Redding	287-288	Right	135
Redding	287.5-288	Left	65
Redding	288.5-290.3	Left	305
Redding	292.5-294	Left	230

Taken from Table 2-2, Appendix A, SLWRI Plan Formulation Report, December 2006, USBR 2006a

Actions associated with this measure would help restore the natural complexity required for a healthy, self-sustaining river ecosystem. Actions would include filling deep pits (potentially requiring suitable fill material to be imported from local sources), recontouring the stream channel and floodplain to mimic natural conditions, and reconnecting the reclaimed area to the Sacramento River. Side channels and other features could be created to encourage spawning and rearing, and restored floodplain lands could be revegetated using native plants. Soil might need to be imported to replenish areas where gravel mining has resulted in a significant loss of fine sediments. Hydrologic, hydraulic, and sedimentation studies would identify optimal restoration conditions and any actions necessary to offset or minimize undesirable hydraulic conditions caused by restoration.

> *This measure consists of acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the Sacramento River to create valuable aquatic and floodplain habitat. Several potential sites for gravel mine restoration along the Sacramento River between Keswick and Red Bluff listed in [Table 3 above].*
>
> *Primary accomplishments of gravel mine site restoration along the upper Sacramento River would be to (1) improve spawning success by increasing the amount of suitable spawning habitat along the Sacramento River for anadromous fish and (2) improve the health and vitality of self-sustaining riverside riparian ecosystems by restoring their connection with natural geomorphologic processes. This measure would support the primary planning objective of increasing the survival of anadromous fish populations in the Sacramento River by eliminating stranding and restoring spawning and rearing habitat at one or more abandoned gravel pits. The measure also would support the secondary planning objective of preserving and restoring ecosystem resources along the upper Sacramento River through restoring riparian and floodplain habitat. This measure would combine favorably with other potential measures to increase fish spawning and rearing along the upper Sacramento River. It would be compatible with plans to modify Shasta Dam because increased cold water releases and other operational changes at the dam would further enhance habitat restored by this measure and increase opportunities for anadromous fish to use the restored habitat. This measure would not conflict with any ecosystem restoration measures that were preliminarily retained. It would also combine favorably with measures involving floodplain restoration along the Sacramento River. This measure would not conflict with other known programs or projects on the upper Sacramento River. The estimated certainty of this measure achieving its intended accomplishments would be very high. Similar restoration projects in other areas have provided favorable, sustainable results. Further, it is estimated that gravel mine restoration would have lasting benefits for the environment because more natural physical and biological processes would be restored area (p. A.2-2, Chapter 2, Appendix A, USBR 2006a).*

The Service believes that the restoration of abandoned gravel mines along the Sacramento River would benefit anadromous fish survival by replacing deep water habitat for predatory fish species (*e.g.*, Sacramento pikeminnow) with spawning habitat for salmonids (Grant 1992). The gravel pits are also a net sink for spawning gravels and large woody debris; therefore, filling in the gravel pits would improve the recruitment of spawning gravels and large woody debris further downstream.

Increase Minimum Anadromous Fish Flows

Two of the initial alternatives considered but removed from further analysis, AFS-2 and AFS-3, contained increasing seasonal minimum flows in the upper Sacramento River from the current 3,250 cfs to about 4,200 cfs between October 1 and April 30 for endangered winter-run Chinook salmon. The 1993 biological opinion for winter-run Chinook salmon (NOAA Fisheries 1993) required minimum flows of 3,250 cfs from October 1 through March 31 to protect rearing juveniles (*i.e.*, assist in downstream migration and help prevent stranding). The 2001 AFRP Final Restoration Plan (USFWS 2001) recommends minimum Sacramento River flows at Keswick Dam for October 1 to April 30 based on October 1 carryover storage in Shasta Reservoir and critically dry runoff conditions (driest decile runoff of 2.5 million af) to produce a target April 30 Shasta Reservoir storage of 3.0-3.2 million af for temperature control (see Table 2). Therefore, the recommendations in the AFRP Final Restoration Plan (USFWS 2001) are based on maintaining sufficient carryover storage in Shasta Reservoir for temperature control for winter-run Chinook salmon.

However, the winter-run Chinook salmon spawning period runs from late April – October with peak spawning in May – June (Table 7; CDFG 1998, Moyle 2002, Vogel and Marine 1991). Therefore, the October 1 to April 30 time period for increasing minimum flows suggested in AFS-2 would not include the winter-run Chinook salmon spawning period. The recommendations and reasonable and prudent measures in the 1993 biological opinion (USFWS 2001) and the AFRP Final Restoration Plan (USFWS 2001) were based on a limited cold water pool available in Shasta Reservoir. However, with improvements to the TCD and an enlarged cold water pool in Shasta Reservoir, increases in minimum flows could also be provided in May – September to improve spawning habitat for endangered winter-run Chinook salmon while still maintaining enough cold water storage for temperature control. If increasing minimum flows were combined with higher Shasta Dam raises (*e.g.*, 18 feet), then both flow and temperature requirements could be met for winter-run Chinook salmon.

Staff at the Service's Red Bluff Fish and Wildlife Office (FWO) observed that when flows from Keswick Dam drop below 4,000 cfs side channels upstream of the Clear Creek confluence (*e.g.*, Girvan Road area) begin to dewater as do other areas upstream near Bonnyview Bridge and near Turtle Bay (T. Kisanuki, Red Bluff FWO, pers. comm., 2007). They also observed that a few fall-run Chinook salmon redds were totally dewatered in the Girvan area side channels of lower Clear Creek when flows out of Keswick dropped below 4,000 cfs (T. Kisanuki, Red Bluff FWO, pers. comm., 2007). Therefore, not allowing the flows to drop below 4,200 cfs would likely benefit fall-run Chinook salmon and other salmonids that utilize these side channels.

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration increasing minimum seasonal flows in the upper Sacramento River. Reclamation stated that:

> *In addition to temperature, river flow is an important factor influencing anadromous fish survival. Flows in the upper Sacramento River are highly influenced by releases from Shasta Dam, particularly during dry years. Higher instream flows would provide access to additional spawning and rearing habitat sites, extend the area of suitable habitat farther downstream, and generally improve aquatic and riparian habitat conditions along the river. Benefits would occur primarily during dryer years, when flows often fall to the current minimum flow of 3,250 cfs. . . Although 4,200 cfs does not represent flows that produce optimal spawning conditions in the river (closer to 5,000 cfs), it is believed to represent a possible balance between the various beneficial uses of the reservoir.*

A preliminary assessment was conducted using an existing hydraulic model of the upper Sacramento River to estimate the increase in available spawning habitat that would occur if flows were increased from 3,250 cfs to 4,200 cfs. Although the preliminary assessment has limitations, it provides a means for comparing the relative performance of the initial plans. On the basis of this assessment, it is estimated that AFS-2 [and AFS-3] could decrease the amount of spawning area between Keswick and Battle Creek that normally becomes dewatered during low flow years by about 170 acres (p. A.4-5 and A.4-6, Chapter 4, Appendix A, USBR 2006a).

The Service agrees with Reclamation that increasing seasonal minimum flows to 5,000 cfs instead of 4,200 cfs (like in AFS-2 and AFS-3) would provide more optimal spawning conditions. The Service also believes that increasing seasonal minimum flows should be combined with Shasta Dam raises of greater than 6.5 feet to evaluate the capability of providing optimal flows and colder temperatures for spawning in the Sacramento River between Keswick Dam and RBDD.

Construct Instream Fish Habitat Downstream from Keswick Dam

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration the construction of instream fish habitat downstream from Keswick Dam. Reclamation stated that:

Keswick Dam is the uppermost barrier to anadromous fish migration on the Sacramento River. Releases from the dam have scoured the channel, and the dam blocks passage of gravels, bed sediments, and woody debris that were replenished historically by upstream tributaries. As a result, aquatic habitat is poor for spawning and rearing of anadromous fish, and predation can be high due to the lack of instream cover. Despite these unfavorable channel conditions, cold water releases from Keswick Dam attract large numbers of spawners to this reach. This measure consists of constructing aquatic habitat in and adjacent to the Sacramento River downstream from Keswick Dam to encourage use of this reach by anadromous fish for reproduction. Habitat restoration would involve acquiring lands adjacent to the Sacramento River; earthwork along the riverbank to construct side channels for spawning; and strategic placement of instream cover structures within the river channel, including large boulders, anchored root wads, and other natural materials.

This measure was deleted from further development as part of the SLWRI primarily because it would have a relatively low potential for sustained success without considerable periodic reconstruction, and operations and maintenance (O&M). High peak flood flows are expected from Keswick Dam for frequent events. It is likely that high flood flows would damage restoration sites and reconstruction would be required for flood events with frequent return periods, every 5 to 10 years. High recurrent O&M responsibilities would adversely affect the potential for sustained project success and result in low Federal interest (pp. A.2-2 and A.2-7, Chapter 2, Appendix A, USBR 2006a).

Nearly all of the spawning of the endangered winter-run Chinook salmon occurs in the Sacramento River between Keswick Dam and RBDD. Therefore, the Service believes that the restoration of instream spawning habitat within this reach of the Sacramento River should be a top priority for the primary planning objective of Anadromous Fish Survival. Due to the canyon-like nature and frequency of high flows immediately downstream from Keswick Dam, the Service believes that instream construction of fish habitat further downstream would likely be more successful.

Replenish Spawning Gravel in the Sacramento River

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration the replenishing of spawning gravel in the Sacramento River. Reclamation stated that:

> *Historically, tributary watersheds upstream from Keswick and Shasta dams provided a continuous source of high-quality gravel and other coarse sediments to the Sacramento River. Today, dams, river diversions, gravel mining, and other obstructions have blocked or reduced natural gravel sources. Gravel suitable for spawning has been identified as a significant influencing factor in the recovery of anadromous fish populations in the Sacramento River. Several programs, including the CALFED Bay-Delta Program (CALFED) and the Anadromous Fish Restoration Program (AFRP), are proceeding with gravel replenishment on the Sacramento River in selected locations. With the exception of the Central Valley Project Improvement Act (b)(13) (CVPIA) program, these programs represent single applications at discrete locations. This measure consists of helping to replenish spawning-sized gravel in the Sacramento River between Keswick Dam and Red Bluff on a long-term basis. Gravel would be transported and injected into the Sacramento River downstream from Keswick Dam. This measure was deleted from further development primarily due to very high ongoing implementation and O&M requirements required for success (pp. A.2-7, Chapter 2, Appendix A, USBR 2006a).*

As stated above, nearly all of the spawning of the endangered winter-run Chinook salmon occurs in the Sacramento River between Keswick Dam and RBDD. Therefore, the Service believes that the restoration of instream spawning habitat between Keswick Dam and RBDD should be a top priority for the primary planning objective of Anadromous Fish Survival. Additionally, Reclamation has obligations through CVPIA and the OCAP biological opinion to inject spawning gravel and develop a gravel management program.

Rehabilitate Inactive Instream Gravel Mines along Stillwater and Cottonwood Creeks

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration the rehabilitation of inactive gravel mines along Stillwater and Cottonwood creeks. Reclamation stated that:

> *Seven inactive gravel pits on Stillwater and/or Cottonwood creeks historically contributed to depletion of nearly all instream gravel resources along various*

reaches, leaving the channel scoured to bedrock. Restoring these gravel mines could help Stillwater Creek provide additional seasonal habitat for various anadromous and resident fish. This measure was deleted from further development primarily because it is a separate and independent action. It would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area (pp. A.2-7 and A.2-8, Chapter 2, Appendix A, USBR 2006a).

Gravel mining on Cottonwood Creek for construction aggregate began in 1901 (CH2M-Hill 2007). Large-scale gravel mining on Cottonwood Creek began in 1960 when Caltrans excavated several hundred thousand cubic yards of gravel for the construction of Interstate 5 (Resource Management International, Inc. 1987). Three active gravel and sand mines continue to operate in Cottonwood Creek (CH2M-Hill 2007).

One of the high priority goals for Cottonwood Creek in the AFRP Final Restoration Plan (USFWS 2001) is to "establish limits on instream gravel mining operations by working with state and local agencies to protect spawning gravel and enhance recruitment of spawning gravel to the Sacramento River in the valley sections of Cottonwood Creek." Gravel mining in Cottonwood Creek and other tributaries significantly reduces the gravel supply to the Sacramento River and contributes to high turbidity and high sediment yields which adversely affect water quality as far away as the Delta (California Department of Water Resources [DWR] 1992). South Fork Cottonwood Creek and Cottonwood Creek are said to be the second and third most turbid streams, respectively, of the 11 westside tributaries north of Thomes Creek (DWR 1992).

Salmonids that emerge as fry in the mainstem Sacramento River utilize the lower reaches of tributaries such as Cottonwood and Stillwater creeks for rearing. Investigations of nonnatal rearing of juvenile Chinook salmon in intermittent tributaries to the Sacramento River found that all tributaries with a near-mouth gradient of less than 1 percent supported non-natal Chinook salmon rearing (Maslin *et al.* 1997). During surveys in February and March, 1997, 291 fall-run, 23 spring-run, and 3 winter-run juvenile Chinook salmon were observed rearing in nonnatal habitat in Stillwater Creek 0.8 km upstream of the confluence with the Sacramento River (Maslin *et al.* 1997). Juvenile Chinook salmon were found as far as 11.5 – 22.1 km upstream in nonnatal tributaries in Thomes Creek, Rock Creek, Mud Creek, and Pine Creek (Maslin *et al.* 1996). Of the juvenile Chinook salmon runs, winter-run were found the farthest upstream in nonnatal tributaries; over 80 percent of winter-run were over 3 km upstream compared to 50 percent of spring-run and 25 percent of fall-run (Maslin *et al.* 1999). The total population of juvenile Chinook salmon rearing in nonnatal tributaries in 1998 was estimated to be between 100,000 and 1,000,000 (Maslin *et al.* 1998); a later study found that the higher the estimate is more likely (Maslin *et al.* 1999).

Juvenile Chinook salmon rearing in the nonnatal tributaries grew faster and were heavier for their length than those rearing in the mainstem (Maslin *et al.* 1996, 1997, 1998, 1999). Faster growing fish smolt earlier, and may enter the Delta earlier in the year, before low water and pumping degrade rearing habitat. Optimal rearing conditions in the tributaries exist from about December through March. Maslin *et al.* (1996) stated that juvenile Chinook salmon entering the tributaries early in the year, such as winter-run and spring-run, probably derive the most benefit from tributary rearing. The authors further stated that "actions may be necessary to protect intermittent stream habitat, and ensure adequate flows and habitat conditions for rearing."

Therefore, the restoration of the lower reaches of Cottonwood and Stillwater creeks would improve rearing habitat for salmonids that emerged within the primary Sacramento River study area (Maslin *et al.* 1996, 1997, 1998, and 1999). Maslin *et al.* (1999) stated that significant restoration of juvenile rearing habitat could be achieved with site-specific projects in tributaries to the Sacramento River including Stillwater Creek. The authors stated that Churn Creek has tremendous potential for both spawning and rearing habitat; the major problem for Churn Creek is dewatering by agricultural extraction (Maslin *et al.* 1997). Thus, the Service disagrees with Reclamation's assumption that the rehabilitation of inactive gravel mines along Stillwater and Cottonwood creeks "would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area."

Another high priority AFRP goal is the establishment, restoration, and maintenance of riparian habitat on Cottonwood Creek (USFWS 2001). The restoration of tributaries is also important for replenishing the recruitment of spawning gravels and large woody debris in the Sacramento River. The initial construction of Shasta Dam blocked the recruitment of spawning gravel and large woody debris from the upper Sacramento, McCloud, and Pit rivers. Therefore, gravel and large woody debris recruitment in the Sacramento River between Keswick Dam and RBDD comes from the tributaries such as Stillwater and Cottonwood creeks. Thus, restoring the inactive gravel pits on Stillwater and Cottonwood creeks would help replenish spawning gravels downstream in the primary Sacramento River study area.

Construct Instream Fish Habitat on Tributaries to the Sacramento River

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration the construction of instream fish habitat on tributaries to the Sacramento River. Reclamation stated that:

> *This measure consists of improving instream aquatic habitat along the lower reaches of tributaries to the Sacramento River. Various structural techniques would be employed to trap spawning gravels in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Both perennial and intermittent streams would be potential candidates for structural habitat improvements. Although this measure would have significant benefits for tributaries, it was deleted from further development as part of the SLWRI primarily because it is a separate and independent action. It would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area (p. A.2-7, Chapter 2, Appendix A, USBR 2006a).*

The Service disagrees with Reclamation's assumption that constructing instream fish habitat on tributaries to the Sacramento River "would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area." The lower reaches of the tributaries to the Sacramento River provide important nonnatal rearing habitat for juvenile anadromous fish that emerged as fry within the primary Sacramento River study (Maslin *et al*. 1996, 1997, 1998, 1999). Therefore, the construction of instream fish habitat on tributaries to the Sacramento River would likely increase the survival rate of emergent fry from the primary Sacramento River study area, and thus would increase the number of adults returning to the primary study area to spawn.

Modify Storage and Release Operations at Shasta Dam

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation retained the modification of storage and release operations at Shasta Dam to improve water flows and quality. Reclamation stated that:

> *In addition to water temperature, flow conditions in the upper Sacramento River are also important in addressing anadromous fish needs. This measure consists of enlarging Shasta Dam and modifying seasonal storage and releases to benefit anadromous fisheries. Although this measure could help provide greater flexibility in meeting water temperature targets, it would be aimed primarily at improving flows and influencing physical channel conditions for anadromous fish. Changes would be made to the timing and magnitude of releases performed to maintain target flows in spawning areas and improve the quality of aquatic habitat by cleaning spawning gravels. This measure would contribute to the goals of the AFRP included as part of the CVPIA. This measure also could include release changes during the flood season to permit "pulse flows" and other releases that could improve aquatic habitat conditions. Further, the measure could provide additional control and dilution of acid mine drainage from Spring Creek.*
>
> *This measure was retained for further development when combined with additional storage space in Shasta Reservoir primarily because it could directly contribute to both primary objectives of the SLWRI and combine favorably with other measures. This measure would not conflict with any other ecosystem restoration measures that were preliminarily retained, nor would it conflict with other known programs or projects on the upper Sacramento River (p. A.2-9, Chapter 2, Appendix A, USBR 2006a).*

However, the modification of storage and release operations at Shasta Dam for improved water flows does not appear in any of the SLWRI alternatives as currently defined in the PFR (USBR 2007). The Service agrees with Reclamation that permitting "pulse flows" during the flood season would improve aquatic habitat conditions. Allowing flood flows during the spring seed dispersal period would also aid in the regeneration of cottonwoods and willows. Cottonwoods and willows provide important SRA cover for salmonids as well as nesting habitat for many migratory birds.

Transfer Existing Shasta Reservoir Storage from Water Supply to Cold Water Releases

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration the transfer of existing Shasta Reservoir storage from water supply to cold water releases. Reclamation stated that:

> *This measure consists of reoperating the existing Shasta Dam and Reservoir for anadromous fishery resources. This measure was requested as part of the*

environmental scoping process. For this measure, it was assumed that storage space in Shasta could be reoperated to provide flows similar to those identified in the January 2001 Final Restoration Plan for the AFRP. This would require an optimal minimum flow along the upper Sacramento River of about 5,500 cfs during certain periods of time. Operational considerations of the increased flows would be given to managing the existing cold water pool in Shasta Reservoir. A cursory estimate was made of the potential water supply yield reduction through increasing the minimum flows from the existing 3,250 cfs to 5,500 cfs. It showed that the loss in drought period yield would amount to about 50,000 af per year. Significant additional fishery modeling studies and water supply related analysis would be necessary to both confirm the magnitude of yield loss and potential benefit to the anadromous fishery. A potential least-cost replacement water source for the yield reduction would likely be in excess of $250 million. This measure was deleted from further consideration primarily because it violates at least one of the planning criteria concerning the potential to adversely impact existing project purposes. In addition, it is believed that the existing Central Valley Project (CVP) water contractors would not be willing to pay for the water loss, and no other entities willing to pay have been identified (p. A.2-10, Chapter 2, Appendix A, USBR 2006a).

The Service believes that Reclamation should evaluate among the SLWRI alternatives the capability of improving flow and temperature conditions for anadromous fish in the Sacramento River between Keswick Dam and RBDD without raising Shasta Dam. This could be accomplished through operational changes at Shasta Dam combined with modifications to the TCD.

Screen Diversions on Old Cow and Cow Creeks

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration screening diversions on Old Cow and Cow creeks. Reclamation stated that:

This measure consists of screening diversion intakes in the Cow Creek watershed to reduce fish mortality. Over 100 agricultural diversions exist from the Cow Creek watershed; while many are small, larger diversions can entrain juvenile salmonids and other fish that use spawning habitat provided by the watershed. This measure would potentially reduce salmonid mortality at diversions within the Cow Creek watershed. However, this measure was deleted from further development primarily because it is an independent action and would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area (p. A.2-11, Chapter 2, Appendix A, USBR 2006a).

The Service disagrees with Reclamation's statement that screening diversions on Old Cow and Cow creeks would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area. The lower reaches of nonnatal tributaries, such as Cow and Old Cow creeks, are important rearing habitat for juvenile salmonids that emerged as fry in the primary Sacramento River study area (Maslin *et al.* 1996, 1997, 1998, 1999). Screening diversions on the lower reaches of nonnatal tributaries would increase the survival rate of juvenile salmonids and the number of adults returning to spawn in the Sacramento River primary study area.

Remove or Screen Diversions on Battle Creek

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration removing or screening diversions on Battle Creek. Reclamation stated that:

> *This measure consists of removing or screening diversions and other water control facilities on Battle Creek to allow full use of the watershed's high-quality, cold water spawning habitat. Several projects have been implemented on lower Battle Creek to improve access to habitat and spawning success, but large portions of the upper Battle Creek watershed remain inaccessible to anadromous fish due to diversions. This measure would provide access to high-quality spawning habitat in the upper Battle Creek watershed. However, this measure was deleted from further development primarily because it is an independent action and would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area (p. A.2-11, Chapter 2, Appendix A, USBR 2006a).*

The Service disagrees with Reclamation's statement that removing or screening diversions on Battle Creek would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area. The lower reaches of nonnatal tributaries, such as Battle Creek, are important rearing habitat for juvenile salmonids that emerged as fry in the primary Sacramento River study area. Removing or screening diversions on the lower reaches of nonnatal tributaries would increase the survival rate of juvenile salmonids and the number of adults returning to spawn in the Sacramento River primary study area.

Cease Operating or Remove the Red Bluff Diversion Dam

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration the removal of or cease operating the RBDD. Reclamation stated that:

> *This measure consists of either ceasing the operation of the Red Bluff Diversion Dam (RBDD) or removing the facility completely. This measure was requested as part of the environmental scoping process. The two primary fish passage issues associated with the RBDD are (1) delay and blockage of adults migrating upstream, and (2) the impedance and losses of juveniles emigrating downstream. Fish ladders located on each abutment of the dam have been ineffective, limiting access to remaining spawning habitat between Keswick Dam and Red Bluff. Predation is also problematic in Lake Red Bluff. Potential solutions to these problems are being considered as part of the Red Bluff Diversion Dam Fish Passage Improvement Project (FPIP). This is a cooperative effort led by Reclamation and the Tehama-Colusa Canal Authority. The project is developing a long-term solution to relieve conflicts between fish passage and agricultural diversion needs. A number of alternatives are being considered, including removing the barrier to fish by removing the gates completely and constructing*

pumps to divert water into the Tehama Colusa Canal, improvements to the existing fish ladders, and construction of a bypass channel. This measure was not considered further in the SLWRI primarily because removing the gates is already one of the alternatives being considered in the FPIP (p. A.2-12, Chapter 2, Appendix A, USBR 2006a).

The Service believes that if the removal or cease in operation of the RBDD is being considered in likely future projects such as the RBDD Fish Passage Improvement Project, then the No Action alternative and the SLWRI alternatives should also include the removal or cease in operation of RBDD as the "likely future" condition. In May 2007, the partial closure of the RBDD was responsible for the death of at least 10 adult green sturgeon including several older gravid females (Darling 2007a, Foott *in litt.* 2007, Bartoo *in litt.* 2007). Additionally, the RBDD increases the risk of predation of juvenile salmonids by Sacramento pikeminnow (Bettelheim 2001, Tucker *et al.* 1998). Therefore, the removal or cease in operation of the RBDD should be included in all SLWRI alternatives.

Reduce Acid Mine Drainage Entering Shasta Lake

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration the reduction of acid mine drainage entering Shasta Lake. Reclamation stated that:

This measure consists of remediating the residual adverse environmental impacts of abandoned former mining operations on aquatic conditions in Shasta Lake and its tributaries. This measure was eliminated from further consideration due to numerous implementation issues (p. A.2-38, Chapter 2, Appendix A, USBR 2006a).

The Service believes that acid mine drainage entering Shasta Lake is a serious human and environmental health issue resulting in toxic levels of trace metals (*i.e.*, zinc, cadmium, copper, and lead) and other contaminants. A U.S. Geological Survey study of metal transport in the Sacramento River (Alpers *et al*. 2000) revealed that acid mine drainage entering Shasta Lake and Keswick Reservoir resulted in elevated concentrations of cadmium, copper, and zinc concentrations in caddisfly larvae at several sites downstream of Keswick Dam. Cadmium showed the highest level of bioaccumulation in whole-body and cytosol analyses with concentrations 5 to 36 times higher than reference caddisfly samples from Cottonwood Creek. In fact, cadmium bioaccumulation persisted in caddisfly larvae samples collected as far as 73 miles (118 kilometers) downstream from Keswick Dam (Alpers *et al*. 2000). Copper and zinc concentrations in caddisflies at Sacramento River sites were 1.4 to 3.0 times greater than concentrations of those at Cottonwood Creek sites. Caddisflies are the preferred diet of juvenile salmonids (Sommer *et al*. 2001b); thus juvenile salmonids in the Sacramento River are particularly at risk of bioaccumulation of toxic levels of cadmium and other trace metals from acid mine drainage entering Shasta Lake and Keswick Reservoir.

State records document more than 20 fish-kill events in the Sacramento River since 1963 related to the uncontrolled discharge of acid mine drainage downstream from Iron Mountain Mine (U.S. Environmental Protection Agency [USEPA] 2006). Acid mine drainage from Iron Mountain Mine killed 100,000 or more fish on separate occasions in 1955, 1963, and 1964 (Nordstrom

1977, CH2M-Hill 1992, USEPA 2006). Remediation and pollution control activities at the Iron Mountain Mine Superfund site now neutralize almost all the acid mine drainage and control 95 percent of the copper, cadmium, and zinc that used to flow into nearby streams and then into the Sacramento River (USEPA 2006).

Another toxicity issue associated with mining in the Shasta Lake area is mercury (Nordstrom *et al.* 1977). Mercury (quicksilver) was used extensively in the gold mining and recovery operations, especially at hydraulic placer mines in the Klamath Mountains but also at mills associated with hardrock mines in both of these areas (Bradley 1918, Alpers *et al.* 2000). Mercury concentrations in water and biota, particularly fish, are major environmental and health concerns in the lower reaches of the Sacramento River and in the Bay-Delta; however, the sources and chemical forms of mercury transported in the Sacramento River remain largely undetermined (Alpers *et al*. 2000).

The raising of Shasta Dam could further exacerbate loading of acid mine drainage into Shasta Lake by inundating or elevating the water table near other abandoned mines and mine tailings. The inundation could increase the rate of loading of copper, cadmium, zinc, and mercury into the water column. During a site visit at Shasta Lake, acid mine drainage with a pH of 2 was observed near the Bully Hill Mine within the Inundation Zone of the SLWRI (P. Uncapher, NSR, pers. comm. 2007). Further loading of acid mine drainage and mercury into Shasta Lake would result in greater increases in toxic cadmium, copper, zinc, and mercury in fish and invertebrates in the lake. These toxic elements would then bioaccumulate within sensitive wildlife raptor species such as the bald eagle and osprey that prey on fish in Shasta Lake. Shasta Lake has the highest concentration of breeding bald eagles in California and should be protected from the adverse affects of acid mine drainage.

The increased loading of cadmium, copper, zinc, and mercury in Shasta Lake could then be transferred downstream through Keswick Dam and into the only known spawning habitat for the endangered winter-run Chinook salmon (Moyle 2002). Of even greater concern is the potential effect that raising Shasta Dam could have on the ability of Keswick Reservoir to dilute acid mine drainage and mercury from the Iron Mountain Mine Superfund site (D. Welsh, Service, pers. comm. 2007). The dilution of acid mine drainage in Keswick Reservoir is essential to preserving vitally important spawning habitat downstream from Keswick Dam. Changes in the operation of Shasta Dam and Keswick Dam in the SLWRI could result in the release of cadmium, copper, zinc, and mercury from sediments in Keswick Reservoir into the water column and the transport of these toxic elements downstream into the Sacramento River (Finlayson *et al.* 2000; D. Welsh, Service, pers. comm. 2007). Increased levels of these toxic elements in the Sacramento River would be transported downstream into the Southern California water supply and into the Delta which is already impaired by high concentrations of mercury and other toxic heavy metals.

Restore Riparian and Floodplain Habitat along the Sacramento River

In the December 2006 PFR (USBR 2006a), Reclamation stated that the restoration of riparian and floodplain habitat along the Sacramento River was retained for further consideration. Reclamation further stated:

Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including numerous threatened or endangered species. Riparian areas also provide shade and woody debris that improve the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat. These areas are seasonally flooded on a frequent basis, interacting with dynamic river processes such as erosion and deposition. Riparian and floodplain terrace habitat along the Sacramento is limited between Keswick Dam and Red Bluff. This is partially due to the natural topography and hydrology of the region; the Sacramento River is naturally more entrenched in this reach, and floodplains are narrow compared with the broad alluvial floodplains found lower in the Sacramento River system. This measure consists of restoring riparian and floodplain habitat along the Sacramento River to promote the health and vitality of the river ecosystem. I t would not conflict with other ecosystem restoration measures that were preliminarily retained or with other known programs or projects on the upper Sacramento River. The restoration would support the goals of the Sacramento River Conservation Area Forum (SRCAF), CALFED, and other programs associated with riparian restoration along the Sacramento River. This measure was retained for consideration primarily because it would have a high likelihood of success in accomplishing effective restoration and would indirectly benefit aquatic habitat conditions for anadromous fish (p. A.2-41, Chapter 2, Appendix A, USBR 2006a).

The Service agrees with Reclamation that the restoration of riparian and floodplain habitat along the Sacramento River would have a high likelihood of success in achieving the secondary objective of Ecosystem Restoration as well as the primary objective of Anadromous Fish Survival. In fact, snorkeling surveys of juvenile Chinook salmon in the middle Sacramento River (river miles (RM) 180 – 230 (a few miles downstream from Ord Ferry upstream to Elder Creek)) suggest that the lack of suitable juvenile rearing habitat may be the most limiting factor for anadromous fish survival; less than 1 percent of the middle Sacramento River is suitable rearing habitat for juvenile Chinook salmon (Cannon 2007).

Riparian vegetation is an important allocthonous (organic matter which enters a lake or river from the atmosphere or drainage basin) source of nutrients and large woody debris into the aquatic ecosystems (Winemiller and Jepsen 1998). Large woody debris increases the production of caddisflies and other invertebrates (Sedell *et al.* 1988, Gurnell *et al.* 1995, Junk *et al.* 1989) which are an important part of the diet of juvenile Chinook salmon (Rondorf *et al.* 1990, Sommer *et al.* 2001b). In fact, accelerated growth rates of juvenile Chinook salmon that reared in the Yolo Bypass floodplain compared to the Sacramento River were attributed to the greater densities of invertebrate prey associated with woody debris (Sommer *et al.* 2001b). Therefore, the dominance of zooplankton in the diets of Sacramento River salmon likely reflects a relatively low availability of other more energetically valuable prey items such as invertebrates associated with woody debris (Sommer *et al.* 2001b).

Restoration of riparian and floodplain habitat should be combined with efforts to eradicate invasive species such as arundo. Despite Reclamation's comments on retaining the restoration of riparian and floodplain habitat along the Sacramento River, this measure no longer appears in the SLWRI alternatives as currently defined in the May 2007 PFR (USBR 2007).

Promote Great Valley Cottonwood Regeneration on the Sacramento River

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration the promotion of Great Valley cottonwood regeneration on the Sacramento River. Reclamation stated that:

> *This measure consists of actively supporting the Great Valley cottonwood regeneration concept along the Sacramento River. This includes working to replace lost floodplain sediment, recontouring floodplains that have disconnected from the river, and revegetating floodplain areas that could support Great Valley cottonwoods. This measure was eliminated from further consideration primarily because (1) there would be major complexities associated with continuing Federal participation in an ongoing broad-scope program in the Sacramento Valley, and (2) it would not directly contribute to accomplishing the primary or other secondary planning objectives.*

The Service disagrees with Reclamation's statement that "there would be major complexities associated with continuing Federal participation in an ongoing broad-scope program in the Sacramento Valley." The promotion of Great Valley cottonwood regeneration on the Sacramento River is a primary restoration goal of SRCAF and AFRP and is currently being considered under Reclamation's North of Delta Storage (NODOS) project. "Ongoing broad-scope" programs are an important part of the monitoring and adaptive management strategy currently used by the Service and Federal partners in ecosystem restoration.

The Service also disagrees with Reclamation's statement that the promotion of Great Valley cottonwood regeneration on the Sacramento River "would not directly contribute to accomplishing the primary or other secondary planning objectives." As stated above, the lack of suitable juvenile rearing habitat in the middle Sacramento River may be the most limiting factor to anadromous fish survival (the primary objective). Promoting cottonwood regeneration and reconnecting the floodplain, would increase SRA cover and backwater habitat for juvenile salmonid rearing. Also, promoting cottonwood regeneration would provide a source of recruitment for large woody debris in the Sacramento River that provides important rearing habitat for juvenile salmonids. The recruitment of large woody debris into the Sacramento River from the upper Sacramento, McCloud, and Pit rivers was cutoff with the initial construction of Shasta Dam. As stated previously, woody debris from riparian vegetation also increases the abundance of caddisflies and other invertebrates that are a significant part of the diet of juvenile Chinook salmon (Rondorf *et al.* 1990, Sommer *et al.* 2001b). Riparian vegetation is also an important allocthonous source of nutrients into the aquatic ecosystem (Winemiller and Jepsen 1998).

Additionally, promoting cottonwood regeneration would also directly achieve the secondary planning objective of Ecosystem Restoration as well as restoring breeding habitat for sensitive migratory birds such as black-headed grosbeak, blue grosbeak, Swainson's hawk, yellow-breasted chat, and yellow-billed cuckoo.

Promoting cottonwood regeneration does not necessarily entail the active restoration and engineering techniques described by Reclamation above. Cottonwood regeneration may be accomplished through “natural” rather than “active” restoration by allowing spring flood flows followed by a slow reduction in river stage (SRCAF 2003). Cottonwood regeneration would respond to pulse flows in April and May if they are followed by a slow reduction in river stage in early summer that allows seedlings to tap into the water table (Roberts *et al.* 2002, Roberts 2003); this could be accomplished during wet years when water supply is not limiting. The NODOS project is currently investigating the capability of providing such pulse flows from RBDD every 10 years in the reach of the Sacramento River between RBDD and Colusa; the water would then be diverted to fill the Sites Reservoir (M. Brown, Red Bluff FWO, pers. comm., 2007).

Reclamation has an obligation under CVPIA Section 3406 (b)(1)A to maintain and restore riparian habitat along the Sacramento River. The regeneration of Great Valley cottonwoods was initially inhibited when the construction of Shasta Dam changed the hydrology of the Sacramento River and reduced spring flood flows important in seed dispersal. The enlarging of Shasta Dam would likely further exacerbate cottonwood regeneration by further reducing spring flood flows.

Preserve Riparian Corridor along Cow Creek

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration preserving the riparian corridor along Cow Creek. Reclamation stated that:

> *This measure consists of protecting and preserving the riparian corridor along Cow Creek. It primarily includes acquiring environmental easements, installing livestock fencing, developing natural vegetation barriers, and replanting streamside grasses, shrubs, and trees. This measure was deleted from considered further consideration primarily because it would not directly contribute to accomplishing the primary or other secondary planning objectives.*

The Service disagrees with Reclamation’s statement that preserving the riparian corridor along Cow Creek “would not directly contribute to accomplishing the primary or other secondary planning objectives.” One of the high priority goals for Cow Creek identified in the Final AFRP Restoration Plan (USFWS 2001) is the fencing of select riparian corridors within the watershed to exclude livestock. As stated above, the lower reaches of nonnatal tributaries, such as Cow Creek, are important rearing habitat for juvenile salmonids that emerged as fry in the primary Sacramento River study area. Preserving the riparian corridor along the lower reaches of Cow Creek would increase SRA cover for juvenile salmonids; this would increase the survival rate of juvenile salmonids and thus the number of adults returning to the Sacramento River primary study area to spawn. Preserving the riparian corridor on the lower reaches of Cow Creek would also directly contribute to the secondary planning objective of Ecosystem Restoration by preserving the riparian corridor along the Sacramento River and its confluence with Cow Creek. Preserving the riparian corridor along the lower reach of Cow Creek would provide a seed bank for the regeneration of riparian vegetation at the confluence with the Sacramento River and further downstream. The initial construction of Shasta Dam reduced the spring flood flows important in the regeneration of cottonwoods and willows along the Sacramento River. An enlarged Shasta Dam would likely further reduce spring flood flows and the ability of cottonwoods and willows to regenerate along the Sacramento River.

A riparian corridor along Cow Creek would also provide a source of recruitment of large woody debris into the Sacramento River. Large woody debris provides important rearing habitat for juvenile salmonids. The recruitment of large woody debris from the upper Sacramento, McCloud, and Pit rivers was cutoff by the initial construction of Shasta Dam. As stated previously, riparian vegetation is an important source of large woody debris which provides, cover, nutrients, and invertebrate prey for juvenile Chinook salmon (Winemiller and Jepsen 1998, Sedell *et al.* 1988, Gurnell *et al.* 1995, Junk *et al.* 1989, Rondorf *et al.* 1990, Sommer *et al.* 2001b).

The primary objective of Anadromous Fish Survival in the SLWRI would be addressed by restoring the riparian corridor along the lower reaches of larger tributaries and smaller intermittent tributaries to the Sacramento River which provide important rearing habitat for juvenile salmonids. Larger tributaries such as Battle Creek that drain snow melt from higher elevations provide constant colder temperature refugia for rearing of juvenile winter-run Chinook salmon that emerged as fry in the primary Sacramento River study area (M. Brown, Red Bluff FWO, pers. comm., 2007). Smaller intermittent tributaries also provide important rearing habitat, especially for juvenile winter- and spring-run Chinook salmon; the warmer temperatures and pulses of organic matter inputs result in higher growth rates of juvenile Chinook salmon that rear in intermittent tributaries compared to the mainstem Sacramento River (Maslin *et al.* 1996, 1997, 1998, 1999). Therefore, preserving the riparian corridor along larger tributaries and smaller intermittent tributaries of the Sacramento River would achieve the primary objective of increasing Anadromous Fish Survival by improving rearing habitat for juvenile Chinook salmon (and steelhead) that emerged as fry in the primary Sacramento River area.

Remove and Control Non-native Vegetation in Cow Creek and Cottonwood Creek

In the December 2006 PFR for the SLWRI (USBR 2006a), Reclamation removed from further consideration removing and controlling non-native vegetation in Cow Creek and Cottonwood Creek. Reclamation stated that:

> *This measure consists of abating exotic vegetation in the Cow Creek and Cottonwood Creek watersheds through removing invasive species from riparian corridors. This measure was deleted from further consideration primarily because it would not directly contribute to accomplishing the primary or other secondary planning objectives.*

The Service disagrees with Reclamation's statement that the removal and control of non-native vegetation in Cow Creek and Cottonwood Creek "would not directly contribute to accomplishing the primary or other secondary planning objectives." Non-native vegetation disperses downstream from Cow and Cottonwood creeks into the primary Sacramento River study area. Therefore, any efforts to control invasive species within the primary Sacramento River study area must also control invasive species upstream and in the lower reaches of the tributaries to the primary study area. Thus, the removal of invasive species along the lower reaches of tributaries to the Sacramento River is necessary for achieving the secondary objective of Ecosystem Restoration within the primary Sacramento River study area.

Currently, a $42,000 grant from the California Department of Food Agriculture is funding the eradication of invasive arundo along a 16-mile stretch of Stillwater Creek (Darling 2007b). Arundo is a noxious weed that dramatically alters the ecological and successional processes in riparian systems and ultimately moves most riparian habitats towards pure stands of this alien grass (Bell 1997). Arundo displaces native vegetation until the riparian area can no longer support a diverse population of native wildlife species. Arundo's destruction of overhanging canopy vegetation allows for greater solar exposure of surface water, resulting in increased water temperatures which may increase to a point where they become lethal for steelhead and salmon. Avian and terrestrial species also lose nesting and foraging habitat. Arundo also alters stream flow and geomorphology. It grows readily on gravel bars and in the streambed, changing flow regimes and directing erosive flows to opposite banks. The flows undercut and destabilize stream banks, causing tree loss, property damage, and siltation. The silt impairs fish spawning grounds, leading to further stress on threatened aquatic specie (Bell 1997, Dale *et al.* 2002, Iverson 1993, Leidy 1998). Therefore, the Service believes that the removal and control on noxious weeds such as arundo on the mainstem Sacramento River and in the tributaries addresses the primary and secondary goals of Anadromous Fish Survival and Ecosystem Restoration, and thus should be a priority in the SLWRI.

EXISTING BIOLOGICAL RESOURCES

This section describes existing fish and wildlife resources and their habitat in the SLWRI project area that could be impacted by project construction activities, inundation, or changes in the operation of Shasta Dam. Because regulatory compliance documents for the SLWRI tier from the programmatic documents prepared for CALFED, the cover-types identified in the SLWRI project area (and described in the Draft EIS/EIR) are based on the cover-types described in the CALFED Multi-Species Conservation Strategy (MSCS) document. Cover-types and habitat descriptions included in this report are generally based on those identified in the Draft EIS/EIR. These habitats and cover-types support several common and special-status wildlife species. The following briefly describes the typical biotic elements of the project area. Due to the requirement in the CALFED programmatic documents for species-specific mitigation and conservation measures for MSCS species, a description of the MSCS species that would be affected by the SLWRI project is also included. A list of the species- and cover-type-specific conservation measures identified for MSCS species in the CALFED programmatic documents is provided in Appendix D of this report. Additional details can be found in the Draft EIS/EIR and ASIP.

Special-status species are plants and wildlife that are (1) designated as rare, threatened, or endangered by the State or Federal governments (Federal and State Endangered Species Acts [ESA and CESA, respectively]; (2) proposed for rare, threatened, or endangered status; (3) are State or Federal candidate species; (4) listed as species of concern by the Service; (5) identified by the CDFG as species of special concern; (6) included on California Native Plant Society (CNPS) List 1A, 1B, 2, 3, or 4; (7) considered sensitive or endemic by the U.S. Forest Service, Shasta-Trinity National Forest (USFS/STNF); (8) considered a Survey and Manage species by the USFS/STNF (NSR 2004); or (9) are considered a CALFED MSCS species.

<u>Primary Study Area: Shasta Lake Vicinity and Tributaries</u>

Aquatic Resources in Shasta Lake and Tributaries

The primary study area for the SLWRI includes aquatic resources in Shasta Lake and its tributaries, Keswick Reservoir, and the upper Sacramento River between Keswick Dam and the RBDD. Shasta Lake collects flow in the upper Sacramento River watershed, but many uncontrolled tributaries enter the Sacramento River downstream from the dam. Stream gages located on various uncontrolled tributaries help the operators of Shasta Dam adjust releases to accommodate downstream peak flows. However, the influence of Shasta's operation on reducing peak flood flows on the Sacramento River diminishes with distance downstream, largely due to these uncontrolled tributaries. Therefore, only the portions of the Sacramento River upstream of the RBDD are included in the primary study area. Table 4 shows fish species known to occur in the primary study area.

Table 4. Fish Species Known to Occur in the Primary Study Area

Common Name	Scientific Name	Shasta Lake Tributaries	Shasta Lake / Keswick Reservoir	Sacramento River - Keswick to Red Bluff
Chinook salmon	*Oncorhynchus tshawytscha*		X	
winter-run				X
spring-run				X
fall-run				X
late fall-run				X
Kokanee salmon	*Oncorhynchus nerka*	X	X	
Rainbow trout/steelhead	*Oncorhynchus mykiss*	X	X	X
Brown trout	*Salmo trutta*	X	X	
Green sturgeon	*Acipenser medirostris*			X
White sturgeon	*Acipenser transmontanus*	X	X	X
Pacific lamprey	*Lampetra tridentata*			X
River lamprey	*Lampetra ayresi*			X
Sacramento sucker	*Catostomus occidentalis*	X	X	X
Sacramento pikeminnow	*Ptychocheilus grandis*	X	X	X
Hardhead	*Mylopharodon conocephalus*	X	X	X
Sacramento blackfish	*Orthodon microlepidotus*	X	X	X
California roach	*Hesperoleucus symmetricus*	X		X
Speckled dace	*Rhinichthys osculus*	X	X	X
Golden shiner	*Notemigonus crysoleucas*	X	X	X
Carp	*Cyprinus carpio*	X	X	X
Channel catfish	*Ictalurus punctatus*	X	X	X
White catfish	*Ameiurus catus*		X	X
Brown bullhead	*Ameiurus nebulosus*		X	X
Black bullhead	*Ameiurus melas*		X	X
Riffle sculpin	*Cottus gulosus*	X	X	X
Rough sculpin	*Cottus asperrimus*	X		
Pit sculpin	*Cottus pitensis*	X		
Prickly sculpin	*Cottus asper*			X
Largemouth bass	*Micropterus salmoides*		X	
Smallmouth bass	*Micropterus dolomieui*	X	X	X
Spotted bass	*Micropterus punctulatus*	X	X	
Black crappie	*Pomoxis nigromaculatus*		X	
White crappie	*Pomoxis annulauris*		X	
Bluegill sunfish	*Lepomis macrochirus*		X	
Green sunfish	*Lepomis cyanellus*	X	X	
Threadfin shad	*Dorosoma petenense*		X	

Adapted from the SLWRI Plan Formulation Report (USBR 2006a)

Shasta Lake and Keswick Reservoir fish species include warm water and cold water species. Shasta Lake tributary species comprise planted and wild trout and several native species. Major nonfish aquatic animal species assemblages of the study area are the benthic macroinvertebrates of Shasta Lake, the Sacramento River, and tributaries to Shasta Lake, and the zooplankton of the reservoirs (USBR 2007).

The fisheries resources of Shasta Lake are greatly affected by the reservoir's thermal structure. During summer months, the epilimnion (warm surface layer) is 30 feet deep and up to 80ºF. Water temperatures above 68ºF favor warm water fishes such as bass and catfish. Deeper water layers, which include the hypolimnion and the metalimnion (transition zone between epilimnion and the hypolimnion), are colder and suitable for cold water species. Shasta Lake is classified as warm monomictic because it has one period of mixing per year. The warm water fish habitats of Shasta Lake occupy two ecological zones: the littoral (shoreline/vegetated) and the pelagic (open water) zones. The littoral zone lies along the reservoir shoreline down to the maximum depth of light penetration on the reservoir bottom, and supports populations of spotted bass, smallmouth bass, largemouth bass, black crappie, bluegill, channel catfish, and other warm water species.

The upper, warm surface layer of the pelagic (open water) zone is the principal plankton-producing region of the reservoir. Plankton comprises the base of the food web for most of the reservoir's fish populations. Operation of the Shasta Dam TCD, which helps conserve the reservoir's cold water pool by accessing warmer water for storage releases in the spring and early summer, may reduce zooplankton biomass, which resides primarily in the reservoir's warmer surface water layer (USBR 2007).

The deeper areas of Shasta Lake, hypolimnion and metalimnion, support cold water species such as rainbow and brown trout and landlocked Chinook and kokanee salmon. Native species such as white sturgeon, Sacramento blackfish, hardhead, rough sculpin, Sacramento sucker, and Sacramento pikeminnow reside in cold water. Trout may congregate near the mouths of the reservoir's tributaries, including the upper Sacramento River, McCloud River, Pit River, and Squaw Creek, when inflow temperatures of these streams are favorable (USBR 2007). The lower reaches of the reservoir's tributaries also provide spawning habitat for reservoir fish populations, and have important resident fisheries of their own (rainbow trout is the principal game species). Most native species found in the reservoir also inhabit the lower reaches of the tributaries. One of the species, the hardhead, is classified as a State of California Species of Special Concern. The McCloud River once supported a population of bull trout, which is currently a Federal and State listed species. The free-flowing stretches of the McCloud River were protected in 1989 under the California Wild and Scenic River Act (Public Resources Code Section 5093.50). A few creeks on the western shore of the reservoir are devoid of biological life due to toxic effluent from local mines (USBR 2007).

Shasta Lake contains approximately 420 miles of shoreline with more than 1,300 identified riverine features entering the lake. In 2002 – 2003, consultants from NSR conducted fluvial geomorphic assessments within the Inundation Zone of 13 of the major tributaries entering Shasta Lake (NSR 2004). All of the reaches except Big Backbone Creek and the Sacramento River are underlain by shallow bedrock.

Keswick Reservoir, an afterbay to Shasta Lake, receives metal-laden acid mine drainage (aluminum, cadmium, copper, iron, and zinc) from abandoned mines in the Spring Creek drainage predominantly from the Iron Mountain Mine Superfund site (U.S. Environmental Protection Agency [USEPA] 1996). Remediation on the site since 1983 has reduced metal loading by more than 80 percent (Finlayson *et al.* 2000) and copper, cadmium, and zinc by 95 percent (USEPA 2006). The discharge of the acid-mine-drainage into Keswick Reservoir produces sediments containing aluminum, cadmium, copper, iron, and zinc. Managing the reservoir and the power plant for peak hydroelectric power generation requires lowering Keswick Reservoir, which can expose the sediments to scouring action, potentially mobilizing metals in the water column and creating conditions toxic to aquatic organisms (Fujimara *et al.* 1995, Finlayson *et al.* 2000). Prior to remediation, uncontrolled discharge of acid-mine drainage from the Iron Mountain Mine resulted in 20 fish-kill events in the Sacramento River since 1963 (CH2M-Hill 1992, USEPA 2006); 100,000 or more fish were killed by acid mine drainage from Iron Mountain Mine on three separate occasions in 1955, 1963, and 1964 (CH2M-Hill 1992, USEPA 2006). The only known spawning habitat for the endangered winter-run Chinook salmon occurs in the Sacramento River immediately downstream from Keswick Reservoir down to the RBDD (Moyle 2002).

Special-status Aquatic Species in Shasta Lake and Tributaries

Special-status aquatic species in Shasta Lake and its tributaries that may be affected by the SLWRI are hardhead, California roach, and rough sculpin. A more detailed discussion of these special-status species is included in Appendix E of this report. The conservation measures recommended by the CALFED Programmatic Final EIR/EIS and ROD (CALFED 2000a,b) are included for the special-status CALFED MSCS species in Appendix D of this report.

Upland and Riparian Resources near Shasta Lake and Tributaries

The primary study area for the SLWRI includes the upland and riparian communities surrounding Shasta Lake within the Inundation Zone and areas that would be directly or indirectly affected by project-related construction and the relocation of campgrounds and other facilities. In 2004, NSR prepared a technical report for Reclamation evaluating upland habitats (Wildlife Habitat Relationship [WHR]) that occur within the 1,070 – 1,090 ft msl elevation range that would be inundated by the proposed maximum Shasta Dam raise of 18.5 ft (Inundation Zone). Upland habitats common within the Inundation Zone include ponderosa pine, montane hardwood, montane hardwood - conifer, mixed chaparral, closed-cone pine, blue oak – gray pine woodland, and montane riparian. Less common upland habitats are annual grassland, blue oak woodland, and Sierran mixed conifer. The quality of the WHR habitat types is evaluated in more detail in the draft Habitat Evaluation Procedures (HEP) Report appended to this report. The following sections discuss the plant and wildlife species found within each WHR type within the Inundation Zone as reported by NSR (NSR 2004). The evaluation species for each WHR type include focal bird species prioritized for conservation by California Partners in Flight (CalPIF) (CalPIF 2000, 2002a, 2002b, 2004, Riparian Habitat Joint Venture [RHJV] 2004) as well as some common and rare (but not federally listed) species associated with each habitat type.

Upland and Riparian Communities near Shasta Lake and Tributaries

Annual Grassland

Annual grassland habitat is uncommon within the Inundation Zone, and occurs as small inclusions within woodland, hardwood, or hardwood-conifer habitats. Dominant species include wild oat, cheatgrass, ripgut brome, yellow starthistle, squirreltail, and European hairgrass (NSR 2004). Annual grassland provides habitat primarily for relatively common wildlife species including native species that require open space, such as the gopher snake, western fence lizard, western king bird, horned lark, red-tailed hawk, California vole, and black-tailed deer.

Blue Oak Woodland

Blue oak woodland habitat occurs mainly as small inclusions or moderate stands in scattered locations within the Pit River portion of the Inundation Zone. This habitat is characterized as open to moderate woodlands dominated by blue oak with occasional interior live oak and gray pine. The shrub layer is open or absent, and a moderate to dense forb layer dominates the understory (NSR 2004). Representative wildlife species include the gopher snake, western fence lizard, barn owl, greater roadrunner, white-breasted nuthatch, ringtail, and coyote. Neotropical migrant birds include ash-throated flycatcher, blue-gray gnatcatcher, and orange-crowned warbler. Several wildlife species in blue oak woodland benefit from acorns as a food source (Schoenherr 1992), including the acorn woodpecker, wild turkey, western scrub jay, yellow-billed magpies, and western gray squirrel. Oak trees also provide shelter for cavity-nesting birds, such as woodpeckers and bluebirds. Blue oak is a slow growing, long lived species and is not regenerating in many parts of its range (Schoenherr 1992).

Blue Oak – Gray Pine

Blue oak – gray pine habitat also occurs as small inclusions and/or moderate stands and is found in the main body of Shasta Lake, Squaw Creek Arm and the Pit River Arm portions of the Inundation Zone. Species composition is similar to the blue oak woodland habitat; however, gray pine and a shrub component are more common. Shrub species include whiteleaf manzanita, poison oak, buckbrush, and western redbud (NSR 2004). Gray pine/oak woodland transitions into blue oak woodland at lower elevations and ponderosa pine forest at higher elevations and, consequently, wildlife species inhabiting gray pine/oak woodland resemble those found in the other two habitats.

Closed-Cone Pine – Cypress

Close-cone pine habitat consists of open to dense knobcone pine stands. This habitat occurs as delineated stands in all portions of the Inundation Zone except along the Big Backbone Creek Arm, where several small inclusions occur within larger habitat types. Closed-cone pine habitat often occurs at locations characterized by disturbances, including historic mining activities and past or recent wildfires. Dominant species include knobcone pine, with occasional ponderosa pine and gray pine. The shrub layer is moderate to dense and is dominated by whiteleaf Manzanita, poison oak, and yerba santa. The ground layer varies and is dominated by various grasses and forbs (NSR 2004).

Mixed Chaparral

Mixed chaparral occurs as variable stands of moderate to dense shrubs, or as small inclusions within other woodland or forest habitats. Dominant species include whiteleaf manzanita, common manzanita, western redbud, buckbrush, deerbrush, poison oak, birch-leaf mountain mahogany, interior live oak (shrub form), silktassel, bush poppy, yerba santa, and brewer oak (NSR 2004). Typical wildlife of mixed chaparral include the gopher snake, western fence lizard, California quail, spotted towhee, lesser goldfinch, black-tailed deer, and gray fox. Neotropical migrant birds include the western tanager and orange-crowned warbler, among others. Mixed chaparral is relatively abundant on the project area and is associated with many common wildlife species, but also provides habitat to important native species, such as neotropical migrant birds.

Montane Hardwood – Conifer

The montane hardwood – conifer habitat is the most abundant vegetation habitat within the Inundation Zone, occurring throughout the area. This habitat includes a variable mixture of conifer and hardwood overstory and trees within an open to dense understory. Dominant conifer species include Douglas-fir, ponderosa pine, gray pine, and knobcone pine. Hardwood composition varies and includes California black oak, canyon live oak, blue oak, and occasional interior live oak. Shrub species and composition vary and include whiteleaf manzanita, western redbud, buckbrush, poison oak, birch-leaf mountain mahogany, brewer oak, and California buckeye. The ground layer varies and is dominated by various grasses and forbs. Wildlife species inhabiting montane hardwood – conifer habitat resemble those found in montane hardwood, ponderosa pine, and closed-cone pine habitats. The special-status Shasta snow-wreath was observed in montane hardwood - conifer habitat within the Inundation Zone along Blue Ridge on the main body of Shasta Lake immediately above the high water line (NSR 2004). Other special-status species known to occur in this habitat type within the Inundation Zone include Pacific fisher, Shasta chaparral snail, Shasta hesperian snail, and several other species of aquatic and terrestrial mollusks (Table 6; NSR 2004).

Montane Hardwood

Montane hardwood habitat includes nearly pure to mixed stands dominated by various hardwood tree species with a variable understory. Dominant tree species include hardwoods, such as California black oak and canyon live oak, with occasional Douglas-fir and ponderosa pine. Shrub species and composition vary and are similar to species occurring in the montane hardwood-conifer habitat (NSR 2004).

Montane Riparian

Montane riparian habitat occurs throughout the Inundation Zone along the many stream and drainages tributary to Shasta Lake. Montane riparian habitat also occurs in isolated spring/seep features scattered throughout the Inundation Zone. Vegetation within this habitat is sparse to dense, mainly occurring in thin to moderate stringers or small patches. In many locations, the adjacent upland habitats often extend into the riparian areas. Dominant species include white alder, black willow, red willow, shining willow, arroyo willow, sandbar willow, Oregon ash, big-leaf maple, buttonwillow, ninebark, mock orange, spice brush, California blackberry, sedges, and various other grasses and forbs. The special-status Shasta snow-wreath was found in montane riparian habitat within the Inundation Zone at five sites, including a very large population on both banks of Stein Creek (Pit River Arm) extending from near the Stein Creek-Shasta Lake confluence to 0.25 mile upstream (NSR 2004). Other special-status species that occur or have the potential to occur in montane riparian habitat within the Inundation Zone and adjacent habitat include foothill yellow-legged frog, northwestern pond turtle, tailed frog, osprey, bald eagle, willow flycatcher, western purple martin, bank swallow, yellow warbler, yellow-breasted chat, Lawrence's goldfinch, Shasta hesperian snail, and several species of aquatic mollusks (Tables 5 and 6; NSR 2004). The northwestern pond turtle likely uses montane riparian habitat within the Inundation Zone for potential nesting sites (NSR 2004). Montane riparian habitat also provides significant SRA cover for migratory birds and fish.

Ponderosa Pine

Ponderosa pine habitat is fairly common in the Project Area and occurs throughout the Inundation Zone. Dominant species include open to moderate stands of ponderosa pine with occasional Douglas-fir, gray pine, and knobcone pine. Dominant hardwoods present include California black oak and canyon live oak. The shrub layer is open to dense and includes whiteleaf manzanita, Brewer oak, snowdrop bush, poison oak, western redbud, and buckbrush. The ground cover is dominated by open to moderate grass and forb cover (NSR 2004). Representative wildlife include the common kingsnake, California slender salamander, sharp-shinned hawk, northern pygmy owl, hairy woodpecker, deer mouse, raccoon, and bobcat. Representative neotropical migrant birds include olive-sided flycatcher, warbling vireo, and western tanager. The special-status Shasta snow-wreath was observed in ponderosa pine habitat within the Inundation Zone along Blue Ridge on the main body of Shasta Lake immediately above the high water line (NSR 2004).

Sierran Mixed Conifer

Sierran mixed conifer habitat is uncommon within the Inundation Zone, occurring at scattered locations along the Squaw Creek Arm portion. This habitat is characterized by a moderate to dense coniferous tree overstory mixed with both overstory and understory hardwoods. Dominant conifer species include Douglas-fir and ponderosa pine, with occasional sugar pine and incense cedar. Dominant hardwoods include California black oak and canyon live oak, with occasional big-leaf maple and Pacific dogwood. Understory vegetation varies and includes sparse to moderate shrub growth, such as whiteleaf manzanita, snowdrop bush, deerbrush, and poison oak, with a variable grass and forb layer. The presence of several conifer tree species and a greater proportion of conifer tree species to hardwood species distinguish this habitat from montane hardwood-conifer habitat. Special-status species known to occur on limestone substrate within this habitat type include the Shasta salamander, Shasta chaparral snail, and Shasta hesperian snail (NSR 2004). CalPIF publishes a list of recommendations and focal species for conserving Sierra Nevada coniferous forest habitat that is essential for birds of California, a large portion of western North America's neotropical migratory birds (Siegel and DeSante 1999).

Special-Status Upland and Riparian Species near Shasta Lake

The location and habitat preference of special-status floral species near Shasta Lake are summarized in Table 5. The location and habitat preference of special-status faunal species near Shasta Lake are summarized in Table 6.

Most of the land within the Inundation Zone consists of Federal lands managed USFS/STNF; therefore, USFS Sensitive and Northwest Forest Plan Survey and Manage species are considered species of concern for the purposes of this evaluation. USFS Sensitive and Survey and Manage species potentially occurring within the Inundation Zone were determined by reviewing available information from the STNF.

Potentially occurring floral species of concern were determined in part by several database searches, a request for and review of a Service species list for Shasta County (USFWS 2003), discussions with resource agency personnel, and professional experience in the inundation Zone area. Additionally, results from the vegetation habitat mapping, botanical surveys, and wildlife surveys conducted within the Inundation Zone by NSR during 2002 and 2003 were used in developing the list of species of concern (NSR 2004).

The California Natural Diversity Database (CNDDB) (CDFG 2007a) was reviewed for records of special-status floral and wildlife species within or in the vicinity of the Inundation Zone. This search produced a list of sightings of floral and wildlife species of concern in the CNDDB within the project vicinity. The CNDDB is a database consisting of historical observation of special-status plant species, wildlife species, and special plant communities. The CNDDB is limited to reported sightings and is not a comprehensive list of floral and wildlife species that may occur in a particular area (CDFG 2007a).

Table 5. Potential Special-status Floral Species near Shasta Lake, California.

Scientific Name	Common Name	Current Status[1]	Comments
Ageratina shastensis	Shasta ageratina	CNPS 4, USFS Endemic	Potentially occurring in limestone outcrop habitats.
Amsinckia lunaris	Bent-flowered fiddleneck	CNPS 1B	Potentially occurring in cismontane woodland and valley and foothill grassland habitats.
Arctostaphylos malloryi	Mallory's manzanita	CNPS 4	Potentially occurring in chaparral and lower montane coniferous forest habitats.
Arnica venosa	Shasta County arnica	CNPS 4	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.
Astragalus pauperculus	Depauperate milk-vetch	CNPS 4	Potentially occurring in chaparral, cismontane woodland and valley and foothill grassland habitats.
Bondarzewia montana (mesenterica)	*Bondarzewia* fungus	S & M (B)	Potentially occurring in mixed conifer and conifer/woodland habitats.
Botrychium inc. B. crenulatum	Moonwort, grape-fern *Botrychium* subgenus	USFS Sensitive	Potentially occurring in mixed conifer and conifer/hardwood habitats.
Botrychium manganese	Moonwort	CNPS 2, S & M (A)	Potentially occurring in mixed conifer and conifer/woodland habitats.
Botrychium montanum	Moonwort	CNPS 2, S & M (A)	Potentially occurring in mixed conifer and conifer/woodland habitats.
Buxbaumia viridis	*Buxbaumia* (bryophyte)	S & M (E)	Potentially occurring in mixed conifer and conifer/woodland habitats.
Calochortus syntrophus	Callahan's mariposa lily	CNPS 3	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.
Calystegia atriplicifoua ssp. buttensis	Butte County morning-glory	CNPS 1B	Potentially occurring in chaparral and lower montane coniferous forest habitats.
Campanula shelteri	Castle Crags harebell	CNPS 1B	Potentially occurring in lower montane conifer habitats.
Carex buxbaumii	Buxbaum's sedge	CNPS 4	Potentially occurring in marshes and swamp habitats.
Carex comosa	Bristly sedge	CNPS 2, MSCS	Potentially occurring marshes and swamps, and valley and foothill grassland habitats.
Carex vulpinoidea	Fox sedge	CNPS 2	Potentially occurring marshes and swamps, and riparian woodland habitats.

Table 5 (continued). Potential Special-status Floral Species near Shasta Lake, California.

Scientific Name	Common Name	Current Status[1]	Comments
Clarkia borealis ssp. *arida*	Shasta clarkia	CNPS 1B, MSCS	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.
Clarkia borealis ssp. *borealis*	Northern clarkia	CNPS 1B	Potentially occurring in chaparral, cismontane woodland and lower montane coniferous forest habitats.
Cryptantha crinita	Silky cryptantha	CNPS 1B, MSCS	Potentially occurring in cismontane woodland, lower montane coniferous forest, riparian forest, riparian woodland, and valley and foothill grassland habitats (gravelly streambeds).
Cypripedium californicum	California lady's-slipper	CNPS 4	Potentially occurring in lower montane coniferous forest habitats.
Cypripedium fasciculatum	Clustered lady's-slipper	CNPS 4, S&M (C)	Potentially occurring in lower montane coniferous forest habitats.
Cypripedium montanum	Mountain lady's-slipper	CNPS 4, S&M (C)	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.
Eleocharis quadrangulata	Four-angled spikerush	CNPS 2, MSCS	Potentially occurring in marshes and swamp habitats.
Fritillaria eastwoodiae	Butte County fritillary	CNPS 3	Potentially occurring in chaparral, cismontane woodland and lower montane coniferous forest habitats.
Lathyrus sulphureus var. argillaceus	Dubious pea	CNPS 3	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.
Lewisia cantelovii	Cantelow's lewisia	CNPS 1B, USFS Sensitive	Potentially occurring in chaparral, cismontane woodland and lower montane coniferous forest habitats. One population found during the 2003 botanical surveys in the Upper Sacramento River Inundation Zone.
Lewisia cotyledon var. howellii	Howell's lewisia	CNPS 3	Potentially occurring in chaparral, cismontane woodland and lower montane coniferous forest habitats.
Limnanthes floccosa ssp. bellingeriana	Bellinger's meadowfoam	CNPS 1B, MSCS	Potentially occurring in cismontane woodland habitats.
Linanthus latisectus	Broad-lobed linanthus	CNPS 4	Potentially occurring in cismontane woodland habitats.
Navarretia subuligera	Awl-leaved navarretia	CNPS 4	Potentially occurring in chaparral, cismontane woodland and lower montane coniferous forest habitats.

Table 5 (continued). Potential Special-status Floral Species near Shasta Lake, California.

Scientific Name	Common Name	Current Status[1]	Comments
Neviusia cliftonii	Shasta snow-wreath	CNPS 1B, USFS Sensitive, MSCS	Potentially occurring in cismontane woodland, lower montane coniferous forest and riparian woodland habitats. Several populations found within Inundation Zone during 2003 botanical and/or vegetation mapping surveys in the Pit River, McCloud River, and Main Body of Lake Inundation Zone.
Otidea leporine	Otidea fungus	S & M (D)	Potentially occurring in mixed conifer and conifer/woodland habitats.
Penstemon filiformis	Thread-leaved beardtongue	CNPS 1B, MSCS	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.
Piperia leptopetala	Narrow-petaled rein orchid	CNPS 4	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.
Polygonum bidwelliae	Bidwell's knotweed	CNPS 4	Potentially occurring in chaparral, cismontane woodland and lower montane coniferous forest habitats.
Polyozellus multiplex	Blue chantrelle	S & M (B)	Potentially occurring in mixed conifer and conifer/woodland habitats.
Potamogeton zosteriformis	Eel-grass pondweed	CNPS 2, MSCS	Potentially occurring in marshes and swamp habitats.
Ptilidium californicum	Pacific fuzzwort	S & M (A)	Potentially occurring in mixed conifer and conifer/woodland habitats.
Rhynchospora capitellata	Brownish beaked-rush	CNPS 2	Potentially occurring in lower montane coniferous forest and marshes and swamp habitats.
Sagittaria sanfordii	Sanford's arrowhead	CNPS 1B, MSCS	Potentially occurring in marshes and swamp habitats.
Schistostega pennata	Bug on a stick	S & M (A)	Potentially occurring in mixed conifer and conifer/woodland habitats.
Scutellaria galericulata	Marsh skullcap	CNPS 2, MSCS	Potentially occurring in lower montane coniferous forest and marshes and swamp habitats.
Sedum paradisum	Canyon Creek stonecrop	CNPS 1B	Potentially occurring in chaparral and lower montane coniferous forest habitats.
Smilax jamesii	English Peak greenbriar	CNPS 1B, USFS Sensitive, MSCS	Potentially occurring in lower montane coniferous forest and marshes and swamp habitats.
(Aleuria) Sowerbyella rhenana	Orange peel fungus	S & M (B)	Potentially occurring in mixed conifer and conifer/woodland habitats.

Table 5 (continued). Potential Special-status Floral Species near Shasta Lake, California.

Scientific Name	Common Name	Current Status[1]	Comments
Stellaria obtuse	Obtuse starwort	CNPS 4	Potentially occurring in lower montane coniferous forest and riparian woodland habitats.
Thermopsis gracilus var. gracilis	Slender false lupine	CNPS 4	Potentially occurring in chaparral, cismontane woodland, and lower montane coniferous forest habitats.
Viburnum ellipticum	Oval-leaved viburnum	CNPS 2	Potentially occurring in chaparral, cismontane woodland, and lower montane coniferous forest habitats.

Notes for Tables 5: Tables adapted from NSR (2004) and updated with data from CDFG (2008b)
[1]Status Definitions:
CNPS 1B = CNPS List 1B Species
CNPS 2 = CNPS List 2 Species
CNPS 3 = CNPS List 3 Species
CNPS 4 = CNPS List 4 Species
USFS Endemic = USFS Endemic Species
USFS Sensitive = USFS Sensitive Species
BLM = BLM Sensitive Species
S & M (-) = USFS Survey and Manage Species
CSC = California Species of Special Concern
CE = California Endangered
CT = California Threatened
CP = California Fully Protected Species
FC = Federal Candidate Species
FT = Federally Threatened
FE = Federally Endangered
FPD = Proposed for Federal Delisting
MSCS = CALFED Multi-species Conservation Strategy species

Table 6. Potential Special-status Faunal Species near Shasta Lake, California.

Scientific Name	Common Name	Current Status	Comments
Shasta salamander	*Hydromantes shastae*	CT, USFS, S & M (A), MSCS	Potentially occurring in mixed conifer, woodland, and chaparral habitats, especially in the vicinity of limestone. Known occurrences within and in the vicinity of the Inundation Zone. Found within the Big Backbone Creek Arm Inundation Zone during 2003 terrestrial mollusk and Shasta salamander surveys.
Tailed frog	*Ascaphus truei*	CSC	Potentially occurring in stream habitats. Known occurrences in McCloud and Upper Sacramento Arm tributaries.
Foothill yellow-legged frog	*Rana boylii*	CSC, USFS, MSCS	Potentially occurring in stream habitats. Known occurrences scattered throughout the Inundation Zone and vicinity.
Northwestern pond turtle	*Actinemys marmorata marmorata*	CSC, USFS, MSCS	Potentially occurring in stream or other wetland habitats. Adjacent upland habitats are potential nesting areas. Known occurrences scattered throughout the Inundation Zone and vicinity.
Double-crested cormorant	*Phalacrocorax auritus*	CSC (Rookery site), MSCS	Potentially occurring in riverine and lacustrine habitats. Mainly a fall/winter migrant, however, also a resident species locally. No known rookery sites within the Inundation Zone.
Osprey	*Pandion haliaetus*	CSC, MSCS	Potentially occurring in riverine and lacustrine habitats. Common at Shasta Lake and many known nests occur within the Inundation Zone and vicinity.
Bald eagle	*Haliaeetus leucocephalus*	CE, BGEPA, CP, MSCS	Potentially occurring in riverine and lacustrine habitats. Common at Shasta Lake and several known nests occur within the Inundation Zone and vicinity.
Sharp-shinned hawk	*Accipiter striatus*	CSC	Potentially occurring in mixed conifer and conifer/woodland habitats.
Cooper's hawk	*Accipiter cooperi*	CSC, MSCS	Potentially occurring in mixed conifer and conifer/woodland habitats.
Northern goshawk	*Accipiter gentilis*	CSC, USFS	Potentially occurring in mixed conifer habitats.
Peregrine falcon	*Falco peregrinus*	CE, USFS, CP, MSCS	Potentially occurring in mixed conifer and conifer/woodland habitats. Nesting sites in the Inundation Zone unlikely due to lack of suitable eyrie sites, however, potential eyrie sites occur adjacent to the Inundation Zone. Known historical eyrie in McCloud River Arm, and "new" eyrie found at the Gooseneck (Sacramento River Arm).

Table 6 (continued). Potential Special-status Faunal Species near Shasta Lake, California.

Scientific Name	Common Name	Current Status	Comments
Northern spotted owl	*Strix occidentalis caurina*	FT, MSCS	Potentially occurring in coniferous forest habitats.
Long-eared owl	*Asio otus*	CSC, MSCS	Potentially occurring in coniferous forest habitats.
Black swift	*Cypseloides niger*	CSC	Potentially occurring in coniferous forest, conifer/woodland, and riparian habitats with waterfall or other mist-zone features.
Vaux's swift	*Chaetura vauxi*	CSC	Potentially occurring in coniferous forest and conifer/woodland habitats.
Little willow flycatcher	*Empidonax traillii brewsteri*	CE, MSCS	Potentially occurring in riparian habitats.
Western purple martin	*Progne subis arboricola*	CSC	Potentially occurring in conifer, woodland, and riparian habitats. Foraging habitat throughout Inundation Zone. Shasta Lake is one of the few known breeding sites in Shasta County.
Bank swallow	*Riparia riparia*	CT, MSCS	Potentially occurring in riparian habitats, foraging habitat throughout Inundation Zone.
Yellow warbler	*Dendroica petechia*	CSC, MSCS	Potentially occurring in riparian habitats.
Yellow-breasted chat	*Icteria virens*	CSC, MSCS	Potentially occurring in riparian habitats.
Western red bat	*Lasiurus blossevillii*	USFS	Potentially occurring in mixed conifer and conifer/woodland habitats, foraging habitat throughout the Inundation Zone.
Spotted bat	*Euderma maculatum*	CSC	Potentially occurring in mixed conifer and conifer/woodland habitats, foraging habitat throughout the Inundation Zone.
Townsend's big-eared bat	*Plecotus townsendii*	CSC, USFS	Potentially occurring in mixed conifer and conifer/woodland habitats, foraging habitat throughout the Inundation Zone.
Pallid bat	*Antrozous pallidus*	CSC, USFS	Potentially occurring in mixed conifer and conifer/woodland habitats, foraging habitat throughout the Inundation Zone.
Greater western mastiff-bat	*Eumops perotis californicus*	CSC, MSCS	Potentially occurring in mixed conifer and conifer/woodland habitats, foraging habitat throughout the Inundation Zone.
Silver-haired bat	*Lasionycteris noctivagans*	USFS S&M	Potentially occurring in mixed conifer and conifer/woodland habitats, foraging habitat throughout the Inundation Zone.

Table 6 (continued). Potential Special-status Faunal Species near Shasta Lake, California.

Scientific Name	Common Name	Current Status	Comments
Ringtail	*Bassariscus astutus*	CP, MSCS	Potentially occurring in mixed conifer and conifer/woodland habitats. Detected at numerous sites during 2003 forest carnivore surveys in Big Backbone and Squaw Creek Arms.
Pacific fisher	*Martes pennanti pacifica*	CSC, FC, USFS	Potentially occurring in mixed conifer and conifer/woodland habitats. Detected at one site each during 2003 forest carnivore surveys in Big Backbone and Squaw Creek Arms.
Shasta sideband	*Monadenia troglodytes troglodytes*	USFS, S & M (A), MSCS	Terrestrial mollusk. Potentially occurring in mixed conifer and woodland habitats, especially in the vicinity of limestone.
Wintu sideband	*Monadenia troglodytes wintu*	USFS, S & M (A)	Terrestrial mollusk. Potentially occurring in mixed conifer and woodland habitats, especially in the vicinity of limestone.
Shasta chaparral	*Trilobopsis roperi*	USFS, S & M (A)	Terrestrial mollusk. Potentially occurring in mixed conifer and conifer/woodland habitats. Found within the Big Backbone Creek and Squaw Creek Arm Inundation Zone during 2003 terrestrial mollusk surveys.
Shasta hesperian	*Vespericola shasta*	USFS, S & M (A)	Terrestrial mollusk. Potentially occurring in mixed conifer and conifer/woodland habitats (riparian and/or riverine habitats). Found within Squaw Creek Inundation Zone during 2003 terrestrial mollusk surveys, also several incidental detections during 2003 in the Pit and McCloud River Arms.
Oregon shoulderband	*Helminthoglypta hertleini*	USFS, BLM	Terrestrial mollusk. Potentially occurring in basaltic talus and other rocky substrates where permanent groundcover, woody debris, and moisture is available. Found along the Big Backbone Creek Inlet, McCloud River Arm, and Pit River Arm (CDFG 2008b).
Nugget pebblesnail	*Fluminicola seminalis*	USFS, S & M (A2)	Aquatic mollusk. Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).
Potem pebblesnail	*Fluminicola sp. 14*	USFS, S & M (A)	Aquatic mollusk. Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).
Flat-top pebblesnail	*Fluminicola sp. 15*	USFS, S & M (A)	Aquatic mollusk. Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).
Shasta pebblesnail	*Fluminicola sp. 16*	USFS, S & M (A)	Aquatic mollusk. Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).

Table 6 (continued). Potential Special-status Faunal Species near Shasta Lake, California.

Scientific Name	Common Name	Current Status	Comments
Disjunct pebblesnail	*Fluminicola sp. 17*	USFS, S & M (A)	Aquatic mollusk. Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).
Globular pebblesnail	*Fluminicola sp. 18*	USFS, S & M (A)	Aquatic mollusk. Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).
Cinnamon juga	*Juga (Orebasis) sp.3*	USFS, S & M (A)	Aquatic mollusk. Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).
Canary duskysnail	*Lyogyrus sp. 3*	USFS, S & M (A)	Aquatic mollusk. Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).
Knobby rams-horn	*Vorticifex sp. 1*	USFS, S & M (E)	Aquatic mollusk. Potentially occurring in mixed conifer and conifer/woodland habitats (seeps, springs, and/or riverine habitats).

Notes for Table 6: Table adapted from NSR (2004) and updated with data from CDFG (2008b)
[1]Status Definitions:
USFS Endemic = USFS Endemic Species
USFS Sensitive = USFS Sensitive Species
BLM = BLM Sensitive Species
S & M (-) = USFS Survey and Manage Species
CSC = California Species of Special Concern
CE = California Endangered
CT = California Threatened
CP = California Fully Protected Species
FC = Federal Candidate Species
FT = Federally Threatened
FE = Federally Endangered
FPD = Proposed for Federal Delisting
MSCS = CALFED Multi-species Conservation Strategy species
BGEPA = Bald and Golden Eagle Protection Act

Additional floral database searches were conducted using the CNPS Electronic Inventory. The Electronic Inventory allows users to query the Inventory of Rare and Endangered Vascular Plants of California (CNPS 2001) using a set of variable search criteria. The criteria used for the CNPS query included all CNPS List 1A, 1B, 2, 3, and 4 plants occurring in Shasta County in closed-cone coniferous forest, chaparral, cismontane woodland, lower montane coniferous forest, marshes and swamps, pebble plain, valley and foothill grasslands, riparian forest, riparian woodland, and riparian scrub habitats between elevations of approximately 900 and 2,500 feet (NSR 2004).

Seven faunal special-status species were observed incidentally during other project-related surveys and activities within the Inundation Zone: foothill yellow-legged frog, northwestern pond turtle, bald eagle, peregrine falcon, western purple martin, ringtail, yellow warbler, and yellow-breasted chat (NSR 2004). A bat cave was also observed within the Inundation Zone during a site visit in July 2007; however, the species of bat observed was unknown. Table 6 lists all special-status faunal species with the potential to occur within the Inundation Zone.

Special-Status Floral Species

The location and habitat preference of special-status floral species near Shasta Lake are summarized in Table 5. Based on habitat present and the elevation range of the dam, 10 special-status plant species were identified as having the potential to occur near Shasta Dam. Seven of these species, adobe lily, Red Bluff dwarf rush, Cantelow's lewisia, Bellinger's meadowfoam, Shasta snow-wreath, Ahart's paronychia, and oval-leaved viburnum are on CNPS List 1B (plants that are rare, threatened, or endangered in California and elsewhere) or CNPS List 2 (plants that are rare, threatened, or endangered in California, but more common elsewhere). Cantelow's lewisia and Shasta snow-wreath are listed as sensitive species by the USFS. The remaining three species, Shasta ageratina, mountain lady's slipper, and dubious pea, are on CNPS List 3 (a review list of plants that require more information on their distribution and abundance) or CNPS List 4 (a watch list for species of limited distribution). Shasta ageratina is listed as sensitive by the USFS because it is endemic to the STNF region. Mountain lady's slipper is considered rare or threatened in the Northwest Forest Plan and is recommended for surveys and management (USBR 2007).

Below is a discussion of a special-status shrub (Shasta snow-wreath) and a rare undescribed plant variety (Shasta huckleberry) that are endemic to the vicinity of Shasta Lake. These plants are likely to be the most adversely affected by the SLWRI. Other special-status plant species in the vicinity of Shasta Lake that may be affected by the SLWRI are discussed in Appendix E of this report. The conservation measures recommended by the CALFED Programmatic Final EIR/EIS and ROD (CALFED 2000a,b) are included for the special-status CALFED MSCS species in Appendix D of this report.

Shasta Snow-Wreath

The Shasta snow-wreath (*Neviusia cliftonii*) is an understory shrub in the rose family that was recently discovered in 1993 (Taylor 1993). The species is endemic to the southeastern Klamath Mountains in northern California (Ertter 1993), occurring in the vicinity of Shasta Lake within an elevational range from 1,070 feet (lake level) to 1,900 feet (Lindstrand 2007). *N. cliftonii* is one of only two known species of the genus *Neviusia*; the other species, Alabama snow-wreath (*N. alabamensis*), is a rare shrub that occurs only in the southeastern United States (Shevock *et al.* 1992). There are 21 known occurrences of the species, nine of which occur on limestone substrate (Lindstrand and Nelson 2005a,b; CDFG 2007a; Lindstrand 2007). The species occurs primarily along drainages in dense, shady montane hardwood-conifer and ponderosa pine forests, but also in foothill pine-blue oak woodland habitat (Lindstrand and Nelson 2005a,b). Populations occur within the Whiskeytown-Shasta-Trinity National Recreation Area, Shasta-Trinity National Forest, and on private land (Shevock 1993). Likely due to the initial construction of Shasta Dam, the remaining populations of Shasta snow-wreath are highly fragmented. There is no genetic information at this time to evaluate how genetically uniform the isolated populations are. Potential threats to the species include logging, mining, forest fires, invasive species, and the proposed raising of Shasta Dam in SLWRI (Shevock *et al.* 1992, CNPS 2007). Shasta snow-wreath is a slow growing species with a tendency to occur in relatively disturbed areas along the edge of the forest thus making the species especially vulnerable to invasive species (*i.e.*, blackberry) and human-related threats (J. Nelson, Shasta-Trinity National Forest, pers. comm, 2007). There is no information available at this time on the effects of fire on Shasta snow-wreath.

Shasta snow-wreath is a USFS sensitive species, a CALFED MSCS species, and a CNPS 1B.2 species. The CALFED Final Programmatic EIS/EIR includes Shasta snow-wreath among a list of "evaluated species for which direct mortality as a result of implementing CALFED actions is prohibited as a condition of the Multi-Species Conservation Strategy [MSCS] . . . .The MSCS requires CALFED to avoid all actions that could result in the mortality of any species identified in this table. This conservation measure was developed because these species are extremely rare. For many of the plants identified, fewer, than a dozen known populations exist" (see Table 4-5 in MSCS section of CALFED 2000b). Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this FWCA report.

During botany surveys and vegetation and habitat mapping surveys (NSR 2004, Lindstrand and Nelson 2005a,b, Lindstrand 2007), Shasta snow-wreath was found at nine sites within the Inundation Zone of the SLWRI. Therefore, 43 percent (9 of 21 subpopulations) of the entire known population of Shasta snow-wreath could be lost (or partly lost) by the proposed raising of Shasta Dam; other subpopulations could potentially be disturbed by the relocation of roads, bridges, campgrounds, and other facilities due to the SLWRI (Lindstrand 2007). The subpopulations found within the Inundation Zone include: (1) a single, relatively large population occurring in riparian habitat along the Ripgut Creek riverine reach (Pit River Arm); (2) a large, previously known population along Campbell Creek (McCloud River Arm); (3) a very large population in riparian habitat along both sides of Stein Creek (Pit River Arm) extending from near the Stein Creek/Shasta Lake confluence to 0.25 mile upstream; (4) a small population found at an unnamed stream south of Cove Creek in riparian and mixed woodland habitat on the right bank, at the confluence with Shasta Lake; (5 and 6) one moderate and one large population along Blue Ridge on the main body of Shasta Lake in hardwood-conifer and ponderosa pine habitats immediately above the Shasta Lake high water line; and (7) a moderate-sized population in riparian habitat along both banks of Keluche Creek (McCloud River Arm) near the Keluche Creek/Shasta Lake confluence (NSR 2004, Lindstrand 2007).

In addition to the nine subpopulations within the Inundation Zone, another eight subpopulations of Shasta snow-wreath are potentially threatened by non-project related activities (*e.g.*, mining, development, fire, invasive species, and other human-related disturbances) due to their location adjacent to State highways, county roads, forest roads, trails, homes, and transmission lines (Lindstrand 2007). Therefore, only 19 percent of all the known populations of Shasta snow-wreath (4 out of 21 subpopulations) are not currently threatened by SLWRI or non-project related activities (Lindstrand 2007).

Shasta Huckleberry

Three populations of an unusual and undescribed huckleberry (unofficially known as "Shasta huckleberry") have been found in the last decade at two locations around Shasta Lake. The huckleberry most closely fits the description of red huckleberry (*Vaccinium parviflorum*) except that the berries of this taxon are dark blue (Nelson 2004). These inland populations are disjunct from the nearest known extant red huckleberry populations by about 40 miles, with the Trinity Alps and other Klamath Ranges lying between them (Nelson 2004). The Shasta huckleberry grows in a distinct, much less mesic habitat than does the coastal red huckleberry and apparently has adapted to grow on low pH soils with unique mineral compositions associated with abandoned mine sites (Nelson 2004; J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007). If Shasta huckleberry is a distinct genetic entity, it is a rare, geographically restricted taxon.

Shasta huckleberry is known from only three locations all near Shasta Lake: (1) scattered patches of shrubs along the Little Backbone Creek drainage from the confluence with Shasta Lake to about 1 mile upstream and uphill to the Golinski Mine; (2) along a road near Bully Hill Mine near the Squaw Creek Arm; and (3) roadside and along a tributary at Shoemaker Gulch along County Road 5G12 to Bohemotash Mountain at an elevation of 2,600 ft (L. Lindstrand, NSR, pers. comm. 2007; J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007). Nine Shasta huckleberry shrubs occur within the Inundation Zone along the Little Backbone Creek drainage and thus are threatened by the SLWRI (L. Lindstrand, NSR, pers. comm., 2007). The Shasta huckleberry shrubs near Bully Hill Mine, while not within the Inundation Zone, are currently threatened by non-project related ground-disturbing activities associated with remediation of acid mine drainage on private land near Bully Hill Mine (J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007; L. Lindstrand, NSR, pers. comm., 2007). Shasta huckleberry shrubs at the Shoemaker Gulch site also occur along a road and are threatened by acid mine drainage and other human-related roadside disturbances (J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007).

In May 2007, a preliminary genetic analysis of five microsatellite loci was conducted for a total of 75 Shasta huckleberry and red huckleberry genetic individuals by the National Forest Genetic Electrophoresis Laboratory in Placerville, California (DeWoody and Hipkins 2007). The genetic analysis indicated that despite the moderate sample size, allelic variation observed at three loci was remarkably high. This indicates that sufficient variation is resolved by these markers to distinguish between individuals and populations; however, the initial interpretations must be considered tentative and require additional collections and potentially different markers before a conclusion may be finalized (DeWoody and Hipkins 2007). Based on the data presented by DeWoody and Hipkins (2007), the genetic analysis is inconclusive; more samples and a different genetic analysis are required to make conclusions about the genetic distinctiveness of Shasta huckleberry.

In summary, at this time, Shasta huckleberry has not been officially identified as a distinct genetic entity; thus Shasta huckleberry has no special-status.

<u>Special-Status Mammals near Shasta Lake</u>

NSR conducted one winter survey (January – February 2003) and one spring survey (March – April 2003) for forest carnivores (carnivore protocol, Zielinski and Kucera 1995) within the Big Backbone Creek Arm and Squaw Creek Arm Inundation Zones. The surveys targeted specific sensitive forest carnivores including Sierra Nevada red fox, American marten, Pacific fisher, and wolverine. Pacific fishers were detected at one survey station in each of the two survey areas. Additional surveys near Shasta Lake in 2004 – 2005 discovered a total of 13 detections of Pacific fisher near Shasta Lake along the mainbody of Shasta Lake and the arms of Big Backbone Creek, Sacramento River, Squaw Creek, and Pit River (Lindstrand 2006). The surveys revealed that the Pacific fisher occurs throughout most of the Shasta Lake area except the McCloud River arm (Lindstrand 2006). The Pacific fisher is a Federal candidate species, a California species of special concern, and an USFS sensitive species. No other sensitive forest carnivore species were detected (NSR 2004).

Other special-status mammals likely to occur in the vicinity of Shasta Lake include ringtail, greater western mastiff-bat, and other species of bats. These special-status mammals likely to occur in the vicinity of Shasta Lake that may be affected by the SLWRI are discussed in Appendix E of this report. The conservation measures recommended by the CALFED Programmatic Final EIR/EIS and ROD (CALFED 2000a,b) are included for the special-status CALFED MSCS species in Appendix D of this report.

<u>Survey and Manage Terrestrial Mollusks near Shasta Lake</u>

Survey and Manage terrestrial mollusk surveys were conducted by NSR during two rounds of surveys in both Big Backbone Creek and Squaw Creek arm portions of the Inundation Zone between December 2002 and February 2003. Four Survey and Manage terrestrial mollusk species were found: Shasta chaparral snail, Shasta hesperian snail, Shasta sideband, and Wintu sideband (NSR 2004, Lindstrand 2007). All 4 of these terrestrial mollusks are endemic to the vicinity of Shasta Lake, and, thus, are likely to be adversely affected by the SLWRI. The survey results, habitat requirements, and known locations of Shasta chaparral snail, Shasta hesperian snail, Shasta sideband snail, and Wintu sideband snail are discussed below. On March 13, 2008, the Center for Biological Diversity petitioned for listing under ESA the 4 terrestrial mollusks among 28 other snails and slugs in the Pacific Northwest (Center for Biological Diversity 2008a,b).

Shasta Chaparral Snail

Shasta chaparral snail (*Trilobopsis roperi*) is a terrestrial mollusk endemic to the southeastern Klamath Mountains in the vicinity of Shasta Lake (Lindstrand 2007). The terrestrial mollusk is known from only 12 sites in Shasta County, California, including 3 sites on non-Federal land and 1 site lost under Shasta Lake (Burke *et al.* 1999, Kelley *et al.* 1999). There are no currently protected occurrences of the species (Burke *et al.* 1999). Shasta chaparral snail is also expected to be found within the Whiskeytown-Shasta-Trinity National Recreation Area (Burke *et al.* 1999). The mollusk may be found within 100 meters of lightly to deeply shaded limestone rockslides, draws, or caves, with a cover of shrubs or oak (Kelley *et al.* 1999). During the wet season, it may be found away from refugia foraging for green vegetation and fruit, feces, old leaves, leaf mold, and fungi (Burke *et al*. 1999). Present knowledge of this species is based on limited collecting from known population areas in the 1930s. Significant data gaps exist in the knowledge of the species' biologic and environmental needs (Burke *et al.* 1999). Local and range-wide population trends are not known (Burke *et al.* 1999). Threats to the species include road building and substantial road maintenance, recreational usage, limestone quarrying, mining, and urbanization in the Redding area (Burke *et al.* 1999, Frest and Johannes 2000). Shasta chaparral snails were detected at 15 sites within the Inundation Zone along the Sacramento River, McCloud River, Squaw Creek, and Pit River arms (NSR 2004, Lindstrand 2007). On March 13, 2008, the Center for Biological Diversity petitioned for listing the Shasta chaparral snail under ESA (Center for Biological Diversity 2008a,b).

Shasta Hesperian Snail

Shasta hesperian snail (*Vespericola shasta*) is a small terrestrial mollusk endemic to Shasta County, California, primarily in the vicinity of Shasta Lake at an elevation of 244-853 meters (800-2,800 feet) (Kelley *et al.* 1999). The snail is known from only seven locations, all within the watershed of the upper Sacramento River in Shasta County (Burke *et al.* 1999). The species has a discontinuous distribution becoming even more fragmented due to climate change, reservoirs, gold mining, and livestock grazing (Burke *et al.* 1999). The Shasta hesperian snail seems to be scarce to moderately common where it does occur, but the known locations are few and widely distributed; the snail species seems to be truly rare and vulnerable to extinction if there were adverse modifications of inhabited locations (Burke *et al.* 1999). Possible threats to the local survival of Shasta hesperian snail include loss of favorable microclimate through reduction or removal of riparian trees, the mechanical disruption of inhabited sites (by motor vehicles and earth-moving machinery), chemical pollution, invasion of the local ecosystem by nonnative plants and animals, and extensive removal of vegetation from watersheds that results in destructive floods and the loss of surface flow (Burke *et al.* 1999). There are no known protected occurrences of the species. Six of the historic locations for this species are within the administrative boundaries of Shasta National Forest (administered as Shasta-Trinity National Forests), but only one current location is known to be on Federal land. The six non-Federal locations are all within 1.6 km (1 mile) of Federal lands (Burke *et al.* 1999).

Shasta hesperian snail has been found in moist bottom lands, such as riparian zones, springs, seeps, marshes, and in the mouths of caves (Kelley *et al.* 1999). The snail seems to be restricted to isolated locations along the margins of streams where perennial dampness and cover can be found. Limestone in the alluvium of the streams of the upper Sacramento River system may contribute to habitat quality for this species. The relatively polished appearance of the shell of this species could be consistent with life in a stony environment--in contrast to other species of Vespericola that have a "furry" appearance and live on the soft surfaces of leaves and rotten wood on damp forest floors (Burke *et al.* 1999).

Shasta hesperian was detected at 31 sites within the Inundation Zone (NSR 2004, Lindstrand 2007). Shasta hesperian is currently designated as Category A species under the Northwest Forest Plan 2002 Survey and Manage Standards and Guidelines category Assignment (Bureau of Land Management [BLM] 2003) (2002 Category Assignment). Taxa in this category are considered rare, and preservation of all known sites or population areas is likely to be necessary to provide reasonable assurance of species persistence. On March 13, 2008, the Center for Biological Diversity petitioned for listing the Shasta hesperian snail under ESA (Center for Biological Diversity 2008a,b).

Shasta Sideband

Shasta sideband (*Monadenia troglodytes troglodytes*) is a terrestrial mollusk endemic to the southeastern Klamath Mountains in the vicinity of Shasta Lake up to an elevation of 3,000 – 3,500 ft (Lindstrand 2007). Shasta sideband occurs within conifer, hardwood-conifer, hardwood, and chaparral general habitat types but appears to be restricted to larger limestone outcrops with deep crevices along the McCloud River arm within the vicinity of Shasta Lake (Roth 1981, Lindstrand 2007). Shasta sidebands were found at four sites within the Inundation Zone along the McCloud River arm (Lindstrand 2007). It is not known at this time what percent of the population occurs within the Inundation Zone. Shasta sideband is a USFS Survey and Manage Species – Category A, a USFS Sensitive species, and a CALFED MSCS species. The CALFED Programmatic EIR/EIS and ROD (CALFED 2000a,b) state that CALFED actions, such as the SLWRI, are prohibited from threatening the population viability of Shasta sideband. All CALFED actions must maintain the status of the Shasta sideband and any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this report. On March 13, 2008, the Center for Biological Diversity petitioned for listing the Shasta sideband snail under ESA (Center for Biological Diversity 2008a,b).

Wintu Sideband

Wintu sideband (*Monadenia troglodytes wintu*) is a terrestrial mollusk endemic to the southeastern Klamath Mountains in the vicinity of Shasta Lake up to an elevation of 3,000 – 3,500 ft (Lindstrand 2007). Wintu sideband, like Shasta sideband, occurs within conifer, hardwood-conifer, hardwood, and chaparral general habitat types but appears to be restricted to larger limestone outcrops with deep crevices in the vicinity of Shasta Lake between the Pit River and Squaw Creek, with one disjunct, outlying population south of Shasta Lake along the Pit River arm within the vicinity of Shasta Lake (Roth 1981, Lindstrand 2007). Wintu sidebands were found at two sites within the Inundation Zone along the Pit River arm (Lindstrand 2007). It is not known at this time what percent of the population occurs within the Inundation Zone. Wintu sideband is a USFS Survey and Manage Species – Category A and a USFS Sensitive species. On March 13, 2008, the Center for Biological Diversity petitioned for listing the Wintu sideband snail under ESA (Center for Biological Diversity 2008a,b).

<u>Special-Status Amphibians and Reptiles near Shasta Lake</u>

Shasta salamander is endemic to Shasta County, California, and thus is the special-status amphibian species likely to be the most adversely affected by the SLWRI. Thus, Shasta salamander is discussed below. Other special-status amphibian and reptile species potentially in the vicinity of Shasta Lake include foothill yellow-legged frog, California red-legged frog, and northwestern pond turtle. These special-status species that may be affected by the SLWRI are discussed in Appendix E of this report. The conservation measures recommended by the CALFED Programmatic Final EIR/EIS and ROD (CALFED 2000a,b) are included for the special-status CALFED MSCS species in Appendix D of this report.

Shasta Salamander

The Shasta salamander (*Hydromantes shastae*) is an uncommon and highly restricted species with a somewhat discontinuous distribution of small, isolated populations occurring in limestone areas (and in some non-limestone areas) in valley-foothill hardwood-conifer, ponderosa pine and mixed conifer habitats in the vicinity of Shasta Lake generally at elevations of 800 – 2,000 ft with a few occurrences between 2,000 – 3,800 ft (Lindstrand 2000; Lindstrand 2007, Morey *et al.* 2005). Each population is unique and vulnerable because of highly restricted habitat requirements (Morey *et al.* 2005). Shasta salamanders feed on centipedes, spiders, termites, beetles, and adult and larval flies (Stebbins 1972, Gorman and Camp 1953). Individuals are active on the surface nocturnally during rainy periods of fall, winter, and spring. Shasta salamander was previously thought to be restricted to limestone fissures and caverns, or deep limestone talus (Morey *et al.* 2005); however, more recently, the species has been found in non-limestone habitat 2.4 – 6.4 km away from the nearest limestone formations (Lindstrand 2000; Lindstrand 2007). Limestone habitats are believed to act as natural reserves for the species during fires (K. Wolcott, Shasta-Trinity National Forest, pers. comm., 2007). The home range of Shasta salamanders is believed to be less than 100 m (328 ft) with most individuals moving much shorter distances (Morey *et al.* 2005). Shasta salamanders breed and lay clusters of 9 to 12 eggs on damp limestone cavern walls in late summer. Young salamanders are thought to hatch in late fall (Gorman 1956, Papenfuss and Carufel 1977). Commercial demand for limestone may jeopardize existing populations (Morey *et al.* 2005).

Shasta salamander surveys were conducted between January – March 2003 within the Inundation Zone in the Big Backbone Creek and Squaw Creek arms. Shasta salamanders were observed at five sites within the Inundation Zone in the Big Backbone Creek survey area, but none were observed in the Squaw Creek survey areas. Shasta salamanders were also observed at two discovery sites during the terrestrial mollusk surveys performed within the Big Backbone Creek arm portion of the Inundation Zone (NSR 2004).

The Shasta salamander is California threatened species and an USFS sensitive and Survey and Manage species. The CALFED Programmatic EIR/EIS and ROD (CALFED 2000a,b) state that CALFED actions, such as the SLWRI, are prohibited from threatening the population viability of Shasta salamander. All CALFED actions must maintain the status of the Shasta salamander and any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this report.

Migratory and Special-Status Bird Species near Shasta Lake

Because birds occupy a wide diversity of ecological niches, they serve as useful tools in the design of conservation efforts (Martin 1995, Askins 2000). Birds are relatively easy to monitor in comparison with other taxa and can serve as "focal species", whose requirements define different spatial attributes, habitat characteristics and management regimes representative of a healthy system. By managing for a group of species representative of important components in a specific functioning habitat type ecosystem, many other species and elements of biodiversity will also be conserved (CalPIF 2002b). Thus, CalPIF maintains a list of focal bird species in its Bird Conservation Plans to guide conservation efforts in grassland, riparian, oak woodland, chaparral, and coniferous forest habitats in California (CalPIF 2000, 2002a, 2002b, 2004, RHJV 2004). A discussion of the CalPIF focal bird species likely to be affected by the SLWRI is included in Appendix E of this report.

Western purple martin is the migratory bird occurring in the vicinity of Shasta Lake that is likely to be the most adversely affected by the SLWRI. Thus, western purple martin is discussed below. Other migratory and special-status bird species in the vicinity of Shasta Lake with the potential to be affected by the SLWRI include California yellow warbler, little willow flycatcher, bald eagle, osprey, American peregrine falcon, long-eared owl, great blue heron, and northern spotted owl. These special-status species that may be affected by the SLWRI are discussed in Appendix E of this report. The conservation measures recommended by the CALFED Programmatic Final EIR/EIS and ROD (CALFED 2000a,b) are included for the special-status CALFED MSCS species in Appendix D of this report.

Western Purple Martin

Western purple martins (*Progne subis arboricola*) are generally uncommon and very local throughout California so all breeding locations are of considerable importance to the species' California range. The Pacific Coast western purple martin population has substantially declined in the last 50 – 100 years primarily due to coastal lowland urban and agricultural development, forest management and fire suppression that have reduced the availability of large snags for nesting use, and increased competition with introduced and European starlings and house sparrows for a dwindling supply of natural nest cavities (Western Purple Martin Working Group 2005). The current population estimate for western purple martins in California, Oregon, Washington, and British Columbia is about 3,500 pairs (1,300 pairs in California) (Western Purple Martin Working Group 2005). Western purple martins nest in small colonies in large snags where there are multiple natural cavities or cavities made by the larger woodpeckers such as acorn and Lewis' woodpeckers and flickers (Siegel and DeSante 1999).

At Shasta Lake, there appears to be a stable population of 18 pairs of purple martins that nest in the inundated snags in the Pit River arm (Lindstrand 2007). These inundated snags were created when the Pit River arm was not logged prior to the initial construction of Shasta Dam. Shasta Lake represents 14 – 51 percent of the total interior Northern California population of western purple martins (Williams 1998). In April and May, western purple martins begin to build there nests in the natural cavities of inundated snags in the Pit River. Western purple martins select for inundated snags and, unlike the more widespread eastern purple martins, they are not known to use artificial structures for nesting. In California, about 85 percent of western purple martins nest in natural cavities with the remaining 15 percent nesting in bridges and power poles (Western Purple Martin Working Group 2005). The interim objective for recovery within California is to retain at least 75 percent of the population nesting in natural cavities (Western Purple Martin Working Group 2005).

A raise in Shasta Dam would likely completely submerge suitable nesting habitat for western purple martins. Although new inundated snags would likely be created by the dam raise, there would be a time lag on the order of decades before the newly inundated snags would provide suitable nesting habitat (G. Boler, NSR, pers. comm, 2007). The western purple martin is a CDFG species of special concern.

Incidental Observations of Non-Status Wildlife near Shasta Lake

In 2003, NSR recorded incidental observation of non-status wildlife species observed during special-status species surveys within the Big Backbone Creek and Squaw Creek arms of the Inundation Zone (NSR 2004). Mammal species observed include the gray fox, black bear, cougar, black-tailed mule deer, wild boar, and spotted skunk. Bird species observed include turkey vulture, Stellar's jay, and raven. Herpetofauna observed include the rough-skinned newt, ensantina, black salamander, western toad, western fence lizard, western skink, northern alligator lizard, sharp-tailed snake, garter snake, and ringneck snake. Non-Survey and Manage terrestrial mollusks observed include Church's sideband, shoulderband, harpoon snail, and California megomphix (NSR 2004).

<u>Primary-Study Area: Sacramento River and Tributaries from Keswick Dam to Red Bluff Diversion Dam</u>

Aquatic Resources

The Sacramento River flows for about 59 miles between Keswick Dam and RBDD. The river in this reach has a stable, largely confined channel with little meander. Riffle habitat with gravel substrates and deep pool habitats are abundant in comparison with reaches downstream from RBDD. Immediately downstream of Keswick Dam, the river is deeply incised in bedrock with very limited riparian vegetation and no functioning riparian ecosystems. Water temperatures are generally cool even in late summer due to regulated releases from Shasta Lake and Keswick Reservoir. Near Redding, the river comes into the valley and the floodplain broadens. Historically, this area appears to have had wide expanses of riparian forests, but much of the river's riparian zone is currently subject to urban encroachment. This encroachment becomes quite extensive in the Anderson/Redding area with homes placed directly within or adjacent to the riparian zone (USBR 2007).

Noxious weeds such as arundo along the Sacramento River and tributaries displace native riparian vegetation that is important habitat for migratory birds. Also, unlike native riparian vegetation, arundo provides very little shade and cover for salmonids resulting in warmer water temperature and little juvenile rearing habitat (Bell 1997). Arundo also affects stream geomorphology changing riparian areas from flood-dominated to fire-dominated ecosystems. It grows readily on gravel bars and in the streambed, changing flow regimes and directing erosive flows to opposite banks. The flows undercut and destabilize stream banks (habitat for bank swallows), causing tree loss, property damage, and siltation. The silt impairs fish spawning grounds, leading to further stress on threatened aquatic species (Bell 1997).

The Keswick to RBDD reach of the Sacramento River contains a large assemblage of resident and anadromous fish species, including commercially important species and species that are listed as threatened or endangered. Since construction of Shasta Dam, this reach continues to have a net loss of suitable gravel and large woody debris that are essential to the spawning and rearing of salmonids. This reach provides much of the remaining spawning and rearing habitat of several listed anadromous salmonids. As such, it is one of the most sensitive and important stream reaches in the State.

The upper Sacramento River system is unique in that it supports four separate runs of Chinook salmon. Each is recognized by its season of upstream migration: fall-, late fall-, winter-, and spring-run Chinook salmon. Runs of fall- and spring-run Chinook salmon also occur on several tributaries of the Sacramento River. The adult population of the four runs of salmon and other important fish species (including steelhead), which also spawn upstream from RBDD, has significantly declined since the 1950s. Today, fall-run, late fall-run and winter-run Chinook salmon stocks and steelhead stocks in the Keswick to RBDD are augmented by production from the Coleman Fish Hatchery on Battle Creek (USBR 2007).

Major factors that contribute to the decline in upper Sacramento River salmon populations include elevated water temperature; passage problems at the RBDD; modification and loss of spawning and rearing habitat due to construction of water resources projects; predation; pollution; and entertainment in water diversions on the Sacramento River and in the Delta. Drought conditions in the late 1980s and early 1990s also significantly contributed to population declines. The construction of the TCD at Shasta Dam improved temperature conditions for anadromous fish spawning and rearing in the Sacramento River immediately downstream from Keswick Dam. However, thermal mortality of anadromous fish may still occur downstream from Keswick Dam during dry and critically dry water years when the cold water pool at Shasta Lake is exhausted. Improvements to the “leaky” TCD would prevent some of the thermal mortality of anadromous fish.

Temperature impacts vary according to life cycle. Maximum survival of incubating salmon and steelhead eggs and yolk-sac larvae occurs at water temperatures between 41 and 56ºF, with no survival occurring at 62ºF or higher. After hatching, sac fry are completely dependent on the yoke sac for nourishment and may tolerate water temperatures up to 58 degrees. After juvenile salmon have emerged from the gravel and become independent of the yoke sac, the young salmon are able to tolerate water temperatures up to 67ºF. Since winter-run and spring-run Chinook salmon spawn during late spring and summer, they are particularly vulnerable to warmer water temperature conditions in the river (USBR 2007).

For a period after Shasta Dam was constructed, the reservoir was kept relatively full and the cold water released from the hypolimnion provided cooler summer temperatures in the downstream reaches. The cold water releases created suitable conditions for winter-run and spring-run salmon to spawn in the mainstem Sacramento River downstream of Keswick dam. Since winter-run Chinook salmon spawning habitat is almost entirely restricted to the Sacramento River between Keswick Dam and the RBDD, winter-run Chinook salmon survival is strongly tied to habitat conditions in this reach. In the late 1980s and early 1990s, because of a series of dry year conditions, storage space in Shasta Lake was decreased to satisfy water demands for agricultural, M&I, and other environmental uses. This decrease in storage resulted in a depletion of the cold water pool, resulting in warmer water in the river and a higher mortality of salmon eggs (USBR 2007).

The NOAA Fisheries biological opinion for winter-run Chinook established water temperature objectives for the river upstream of Jellys Ferry (near RBDD) of 56ºF from April 15 through September 30, and 60ºF for October (NOAA Fisheries 1993). Recent changes in reservoir operations, including greater carryover storage, increased imports of cold water from the Trinity River system, and, most importantly, installation of a TCD on Shasta Dam, have substantially improved water temperature conditions in the reach.

The PFR (USBR 2007) reports the following problems in the Sacramento River affecting anadromous fish:

- RBDD impedes upstream migrating adults and downstream migrating juveniles; current operation of the RBDD includes a 4-month period (May 15 through September 15) when the dam gates are placed in the river, creating a velocity barrier that prevents upstream migrating adult salmon and steelhead from passing under (or over) the dam. However, the entire population of winter-run and spring-run Chinook salmon that spawn in the Sacramento River must spawn upstream of the RBDD for reliable reproductive success because the RBDD is the downstream limit of temperature control for Shasta Dam (USBR 1991).

- Glenn-Colusa Irrigation District (GCID) pumps divert up to 3,000 cubic feet per second (cfs) and approximately 1 million af (MAF) of water annually through inadequate fish screens. GCID recently replaced its cylindrical fish screens with a flat-plate screen.

- Anderson-Cottonwood Irrigation District's (ACID) seasonal flashboard dam in Redding diverts up to 400 cfs, and impedes upstream migrating adults and downstream migrating juveniles. ACID constructed a new diversion facility with fish ladders in 2002.

- Access to historical spawning and rearing habitat is restricted.

- Hundreds of small unscreened diversions entrain fish.

- Bank protection projects reduce available remaining habitat.

- High water temperatures associated with reservoir storage decrease fish habitat. Reclamation constructed the Shasta TCD on the upstream face of Shasta Dam to access deeper and cooler water for downstream water temperature control and power generation.

- Discharges of chemical waste from M&I and agricultural sources decrease the quality of fish habitat; remedial efforts at Iron Mountain Mine and the construction and operation of Spring Creek Debris Dam have helped to reduce heavy metal and acid waste from Iron Mountain Mine, and chronic contamination from numerous and widespread sources.

Numerous tributaries to the Sacramento River are important for the recruitment of gravel and large woody debris into the mainstem Sacramento River. These tributaries include colder perennial streams and warmer intermittent streams both of which provide important nonnatal rearing habitat for salmonids that emerged as fry in the mainstem Sacramento River. The perennial streams provide a constant flow of colder water from the higher elevations. The intermittent streams provide pulses of organic matter inputs and warmer temperatures which accelerate the growth rate of juvenile salmonids that emerged as fry in the mainstem Sacramento River (Maslin *et al.* 1996, 1997, 1998, 1999). Some of the tributaries also provide important spawning habitat for salmonids (*e.g.*, Battle Creek, Clear Creek, Cottonwood Creek, Bear Creek, and Cow Creek). Therefore, based on the importance of these tributaries to the survival salmonids in the mainstem Sacramento River, the Service believes that the primary study area for the SLWRI should be expanded to include the lower reaches of these tributaries. Additionally, it is believed that the downcutting of the tributaries and current loss of riparian habitat is due to the reduction in flood flows in the Sacramento River since the construction of Shasta Dam. Thus, a further reduction in flood flows in the Sacramento River with the raising of Shasta Dam could result in further downcutting of the tributaries and loss of riparian habitat.

Special-Status and Target Aquatic Species in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam (RBDD)

Four runs of Chinook salmon, steelhead, and green sturgeon compose the anadromous salmonid fishery in the Sacramento River between Keswick Dam and RBDD. Because increasing the survival of these fish is one of the primary goals of the Project, basic life history information is provided below. The generalized life history timing of the four runs of Central Valley Chinook salmon is summarized in Table 7 below. More-detailed life history patterns and the general timing of Chinook salmon and steelhead runs in the Sacramento River between Keswick Dam and the RBDD are described in the SLWRI Project ASIP, which serves the purpose of a Biological Assessment for consultation under section 7 of the ESA.

Table 8 was taken from the SLWRI PFR (USBR 2006a). The table summarizes the special-status species known to occur in the Sacramento River between Keswick Dam and RBDD. However, the table omits green sturgeon. In May – June 2007, 10 adult green sturgeon, ranging in size from 4 – 7 feet, were found battered and dead near the RBDD (Darling 2007a, Foott *in litt.* 2007, Bartoo *in litt.* 2007). Two of the dead sturgeon were identified as older gravid females. It is believed that the sturgeon were attempting to move downstream and got caught in the narrow opening underneath several of the gates at RBDD. The force of the water moving under these gates likely forced the sturgeon into the opening and pinned them there. Thirty-five green sturgeon were seen to have passed the dam. Currently, Reclamation is consulting with NOAA Fisheries and the Service on the RBDD Fish Passage Improvement Project.

Major factors that contribute to the decline in upper Sacramento River salmon populations include elevated water temperature; passage problems at the RBDD; modification and loss of spawning and rearing habitat due to construction of water resources projects; predation; pollution; and entrainment in water diversions on the Sacramento River and in the Delta. Drought conditions in the late 1980s and early 1990s also significantly contributed to population declines. Of these influencing factors, water temperature is one of the most important.

Table 7. Generalized Life History Timing of Central Valley Chinook Salmon Runs.

Run	Adult Migration Period	Peak Migration Period	Spawning Period (1)	Peak Spawning Period	Fry Emergence Period	Juvenile Stream Residency	Juvenile Emigration Period
Late fall	Oct – Apr	Dec	Early Jan – Mar	Feb – Mar	Apr – Jun	7-13 months	Apr – Dec
Winter	Dec – Jul	Mar	Late Apr – Oct	May – Jun	Jul – Oct	5-10 months	Jul – Apr
Spring(2)	Mid-Feb – Jul	Apr – May	Late Aug – Dec	Mid-Sep	Nov – Mar	3-15 months	Oct – Mar
Fall	Jul – Dec	Sep – Oct	Late Sep – Mar	Oct – Nov	Dec – Mar	1-7 months	Dec – Jun

Sources:
(CDFG 1998; Moyle 2002; NOAA Fisheries 2004a; Vogel and Marine 1991).

Note:
1 The time periods identified for spawning include the time required for incubation and initial rearing, before emergence of fry from *spawning* gravels.
2 There are no known spawning populations of spring-run Chinook salmon in the Sacramento River upstream of the Red Bluff Diversion Dam (Benthin *in litt*. 2006). However, spring-run Chinook salmon are thought to pass the RBDD to spawn in tributaries to the Sacramento River such as Battle Creek, Clear Creek, and Cottonwood Creek (CDFG 2004).

Fortunately, cold water released from Shasta Dam significantly helps support spawning habitat in the reach below Keswick Dam. Without these cold water releases, winter-run Chinook salmon would possibly have become extinct, otherwise dispossessed of their historic spawning streams. However, temperatures still rise to levels harmful to salmon and steelhead.

Special-status warmer water fish that occur in the Sacramento River between Keswick Dam and RBDD include hardhead and California roach. A discussion of the special-status salmonids and warmer water fish species in the Sacramento River between Keswick Dam and RBDD is provided in Appendix E of this report.

Upland and Riparian Resources

This section discusses the upland and riparian vegetation communities that occur within the primary study along the Sacramento River between Keswick Dam and RBDD. These vegetation communities may be affected by changes in the timing and duration of flood flows in the Sacramento River due to the SLWRI. Also, the restoration of riparian and oak woodland communities along the Sacramento River is being considered within the SLWRI alternatives.

Vegetation within the Sacramento River Valley includes a variety of both upland and lowland plant communities, including a number of communities that are considered sensitive. Common plant communities present within the primary study area include annual grassland, blue oak woodland/savanna, foothill pine-oak woodland, chaparral, and agricultural lands. The upper banks along steep-sided, bedrock constrained segments of the Sacramento River and its tributaries are characterized primarily by upland communities including blue oak woodland, foothill pine-oak woodland, and chaparral. These incised segments occur primarily between Shasta Dam and Redding (USBR 2007).

Table 8. Special-status Fish and Wildlife Species Known or with Potential to Occur in the Primary Study Area, Along the Sacramento River from Shasta Dam to Red Bluff Diversion Dam

Common Name	Scientific Name	Legal Status USFWS	Legal Status CDFG	General Habitat
Federal and State Threatened and Endangered Species				
American peregrine falcon	*Falco peregrinus anatum*	D	E	Riparian zones for wintering habitat
Bald eagle	*Haliaeetus leucocephalus*	T	E	Riparian zones along larger rivers and open water areas with large trees for nesting and roosting
Bank swallow	*Riparia riparia*	--	T	Steep river banks and banks near water sources
California red-legged frog	*Rana aurora draytonii*	T	SC	Still or slow-moving water with shrubby riparian vegetation, thought to be extripated from the Sacramento Valley floor
Chinook salmon, fall/late fall-run	*Oncorhynchus tshawytscha*	C, CH	SC	Sacramento River and tributaries
Chinook salmon, spring-run	*Oncorhynchus tshawytscha*	T, CH	T	Sacramento River and tributaries
Chinook salmon, winter-run	*Oncorhynchus tshawytscha*	E, CH	E	Sacramento River and tributaries
Conservancy fairy shrimp	*Branchinecta conservatio*	E, CH	--	Vernal pools and swales
Ringtail	*Bassariscus astutus*	--	FP	Chaparral and riparian areas
Steelhead, Central Valley	*Oncorhynchus mykiss*	T, CH		Sacramento River and tributaries
Swainson's hawk	*Buteo swainsoni*	--	T	Riparian areas with large trees for nesting; adjacent open lands for foraging
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	T	--	Riparian; requires elderberry shrubs with base diameters of 1-inch or greater
Vernal pool fairy shrimp	*Branchinecta lynchi*	T, CH	--	Vernal pools
Vernal pool tadpole shrimp	*Lepidurus packardi*	E, CH	--	Vernal pools and swales
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	C	E	Riparian forest and scrub
White-tailed kite	*Elanus leucurus*	SC	FP	Lowland grasslands, agriculture, wetlands, oak-woodland and savannah habitats, and riparian areas associated with open areas for foraging
Willow flycatcher	*Empidonax traillii*	--	E	Riparian areas

Table copied from the SLWRI Plan Formulation Report (USBR 2006a). Note that the table needs to be updated to include green sturgeon based on observations of the fish above RBDD in May – June 2007 (Foott *in litt*. 2007, Darling 2007a, Bartoo *in litt*. 2007).

Table 8 (continued). Special-status Fish and Wildlife Species Known or with Potential to Occur in the Primary Study Area, Along the Sacramento River from Shasta Dam to Red Bluff Diversion Dam

Common Name	Scientific Name	Legal Status USFWS	Legal Status CDFG	General Habitat
Federal and State Species of Special Concern				
Burrowing owl	*Athene cunicularia*	--	SC	Burrows within grasslands
Black tern	*Chlidonias niger*	--	SC	Marsh lands with permanent open water
California gull	*Larus californicus*	--	SC	Wintering populations only; riverine and wetlands
California horned lark	*Eremophila alpestris actia*	--	SC	Grasslands
California thrasher	*Toxostoma redivivum*	SC	--	Riparian and chaparral
Cooper's hawk	*Accipiter cooperi*	--	SC	Riparian zones
Ferruginous hawk	*Buteo regalis*	SC	SC	Wintering populations in grasslands
Foothill yellow-legged frog	*Rana boylii*	SC	--	Shallow rivers and streams with gravel bottoms
Fringed myotis bat	*Myotis thysanodes*	SC	--	Grasslands, orchards, buildings, and mixed woodlands
Hardhead minnow	*Mylopharodon conocephalus*	--	SC	Reservoirs and mid-elevation streams tributary to the main Sacramento River
Lawrence's goldfinch	*Carduelis lawrencei*	SC	--	Oak woodland, chaparral, and riparian woodland, usually near water
Least bittern	*Ixobrychus exilis*	--	SC	Wetlands with emergent vegetation
Lewis' woodpecker	*Melanerpes lewis*	SC	--	Riparian, savanna, orchard, and mixed woodland; nests in snags and hollow trees
Loggerhead shrike	*Lanius ludovicianus*	SC	SC	Cropland, grassland, savanna, and chaparral
Long-billed curlew	*Numenius americanus*	SC	SC	Herbatious wetands, grasslands, and riparian areas
Long-eared myotis bat	*Myotis evotis*	SC	--	Forages over water and among trees; roosts in snags
Longfin smelt	*Spirinchus thaleichthys*	SC	SC	Lower Sacramento River
Long-legged myotis bat	*Myotis volans*	SC	--	Riparian, grasslands, and mixed woodlands
Merlin	*Falco columbarius*	--	SC	Riparian zones for wintering habitat
Northwestern pond turtle	*Clemmys marmorata marmorata*	--	SC	Moderate to deep slow-moving rivers; ponds and streams with deep pools
Nuttall's woodpecker	*Picoides nuttallii*	SLC	--	Oak forest and woodland, chaparral, and riparian habitats
Oak titmouse	*Baeolophus inornatus*	SLC	--	Riparian woodlands and arborescent chaparral
Osprey	*Pandion haliaetus*	--	SC	Riparian zones along the Sacramento River and open water areas with large trees for nesting and roosting
Pacific western big-eared bat	*Corynorhinus (Plecotus) townsendii townsendii*	SC	SC	Mesic sites with suitable roosts and low human disturbance
Purple marten	*Progne subis*	--	SC	Riparian forests
Rufous hummingbird	*Selasphorus rufus*	SC	--	Migrant throughout primary study area

Table 8 (continued). Special-status Fish and Wildlife Species Known or with Potential to Occur in the Primary Study Area, Along the Sacramento River from Shasta Dam to Red Bluff Diversion Dam

Common Name	Scientific Name	Legal Status USFWS	Legal Status CDFG	General Habitat
Federal and State Species of Special Concern (continued)				
Sacramento splittail	*Pogonichthys macrolepidotus*	D	SC	Sacramento River
San Joaquin pocket mouse	*Perognathus inornatus*	SC	--	Grasslands
Sharp-shinned hawk	*Falco columbarius*	--	SC	Riparian zones
Short-eared owl	*Asio flammeus*	--	SC	Open areas, grasslands, and irrigated pasture
Small-footed myotis bat	*Myotis ciliolabrum*	SC	--	Riparian, woodlands, and chaparral
Tricolored blackbird	*Agelaius tricolor*	--	SC	Emergent wetlands
Vaux's swift	*Chaetura vauxi*	SC	SC	Migrant throughout primary study area; foraging for insects in flight over rivers
Western spadefoot toad	*Spea hammondii*	SC	SC	Vernal pools, ponds, and adjacent uplands
White-faced ibis	*Plegadis chihi*	SC	SC	Irrigated pastures and shallow wetlands
Yellow warbler	*Dendroica petechia brewsteri*	--	SC	Riparian woodlands
Yellow-breasted chat	*Icteria virens*	--	SC	Riparian woodlands
Yuma myotis bat	*Myotis yumanensis*	SC	--	Moist woodlands and forests near open water
Additional Species in the Extended Study Area				
Delta smelt	*Hypomesus transpacificus*	T	T	Sacramento River Delta
Green sturgeon	*Acipenser medirostris*	--	FP, SC	Sacramento River
River lamprey	*Lampetra ayresi*	SC	SC	Lower Sacramento River

Sources: USFWS 2006, CNDDB 2005, NatureServe 2006, and CDFG 2006a.
Key:
U.S. Fish and Wildlife Service (USFWS) Federal Listing Categories:
T = Threatened
E = Endangered
SC = Species of Concern to the Sacramento Fish and Wildlife Office
D = Delisted and monitored for 5 years
SLC = Species of Local Concern to the Sacramento Fish and Wildlife Office
CH = Critical habitat for the species occurs within the project's primary study area

California Department of Fish and Game (CDFG) State Listing Categories:
T = California Threatened
E = California Endangered
SC = Species of Special Concern
FP = Fully protected by the State, a designation given to species prior to the adoption of the CESA
C = Candidate for listing as threatened or endangered

Historically, the Sacramento River was bordered by up to 500,000 acres of riparian forests, with valley oak woodland covering the higher river terraces (Katibah 1984). Approximately 23,000 acres (11 percent of the original amount) of riparian habitat and valley oak woodland remain within the Sacramento River corridor (SRCAF 2003). By the 1980s less than 5 percent of the Sacramento River's riparian habitat remained (SRCAF 1989). State Senate Bill 1086, which passed in 1986, established the Upper Sacramento River Fisheries and Riparian Habitat Advisory Council and called for a management plan to protect, restore, and enhance fish and riparian habitat and associated wildlife of the upper Sacramento River. Thus, a management plan was developed by SRCAF. The management plan for the Sacramento River Conservation Area (SRCAF 1989) identifies specific actions that will help restore the Sacramento River fishery to its optimum state and protect and restore riparian habitat. An additional document, the Sacramento River Conservation Area Handbook (SRCAF 2003), was also prepared by the SRCAF which provides river managers with a framework of ecology and policy to guide on the ground decisions.

The Keswick - Red Bluff section of the Sacramento River Conservation Area encompasses 22,000 acres of the 100-year floodplain and contiguous valley oak woodland, ranging in width from more than one-mile wide in the broad alluvial area Bloody Island to only 500 feet in the confined canyon near Table Mountain and within Iron Canyon (SRCAF 2003). There are currently 4,674 acres of riparian habitat within the Keswick-Red Bluff section of the Conservation Area (SRCAF 2003). The broad alluvial portion of the reach between Redding and Balls Ferry has the potential to support significant tracts of riparian forest (SRCAF 2003). Historically, the river between Redding and Anderson supported several gravel mining operations (SRCAF 2003).

Upland Communities

Oak Woodlands

Oak woodlands present in the study area include blue oak woodland, valley oak woodland, and foothill pine-oak woodland. Of these oak woodland types, only valley oak woodland is identified as a sensitive natural community by CDFG. However, other oak woodland communities and individual oak trees may be protected under local ordinances. Valley oak woodland consists of an open savanna of valley oak trees and an annual grassland understory. Valley oak is typically the only tree species present and shrubs are generally absent except for occasional poison oak. Canopy cover rarely exceeds 30 percent to 40 percent in valley oak woodland. This community occupies the highest portions of the floodplain terrace where flooding is infrequent and shallow (USBR 2006a). The presence of valley oak has a positive influence on yellow warbler and song sparrow abundance (RHJV 2004).

Riparian Communities

Much of the vast riparian habitat that once existed along the Sacramento River has been eliminated by agricultural clearing, flood control projects, and urbanization. Historically, belts of riparian forest over 5 miles wide occurred along the Sacramento River (Jepson 1893, Thompson 1961, Hunter *et al.* 1999). Only narrow remnants of these riparian forests remain in the Sacramento River Valley. The river corridor between Redding and Red Bluff, however, maintains a larger percentage of riparian vegetation than is typical along the lower reaches of the Sacramento River. Riparian communities present within the 100-year floodplain of the Sacramento River, within the study area, include blackberry scrub, Great Valley willow scrub, Great Valley cottonwood riparian forest, Great Valley mixed riparian forest, and Great Valley valley oak riparian forest. Willow and blackberry scrub and cottonwood and willow dominated riparian communities are present along active channels and on the lower flood terraces whereas valley oak dominated communities occur on higher flood terraces. Much of the Sacramento River from Shasta Dam to Redding is deeply entrenched in bedrock, which precludes development of riparian vegetation.

Riparian communities in the primary study area are subject to CDFG regulation under Section 1602 of the California Fish and Game Code because they are associated with stream banks and are identified as sensitive natural communities by CDFG because of their declining status statewide and because of the important habitat values they provide to both common and special-status plant and animal species. These habitat types are tracked in the CNDDB. In addition, areas containing riparian habitat may be subject to the Corps jurisdiction under Section 404 of the Clean Water Act (CWA).

Shaded Riverine Aquatic Cover

SRA cover is defined as the nearshore aquatic area occurring at the interface between a river (or stream) and adjacent woody riparian habitat. The principal attributes of this valuable cover-type include: (a) the adjacent bank being composed of natural, eroding substrates supporting riparian vegetation that either overhangs or protrudes into the water, and (b) the water containing variable amounts of woody debris, such as leaves, logs, branches and roots, as well as variable depths, velocities, and currents (USFWS 1992). These attributes provide high-value feeding areas, burrowing substrates, escape cover, and reproductive cover for numerous regionally important fish and wildlife species, including the State- and federally-listed winter-run Chinook salmon and the State-listed bank swallow. However, this cover-type on the Sacramento River and its major tributaries has been rapidly lost over the past 30 years, primarily due to bank protection projects such as the U.S. Army Corps of Engineers' (Corps) Sacramento River Bank Protection Project. Since 1961, the Corps has constructed over 140 miles of riprapped riverbanks in the Sacramento River system. As a result, we estimate that only 7 percent of historic SRA cover remains in the lower Sacramento River and its four major sloughs (USFWS 1992). Recent snorkeling surveys show that due to the loss of SRA cover, less than 1 percent of the middle Sacramento River (*i.e.*, river miles 180 – 230 (a few miles downstream from Ord Ferry up to Elder Creek)) currently provides suitable rearing habitat for juvenile Chinook salmon (Cannon 2007).

Blackberry Scrub

Blackberry scrub is dominated by Himalayan blackberry, a species that is listed as invasive by the California Invasive Plant Council. Cover of Himalayan blackberry is extremely dense in this community leaving little opportunity for the establishment of native tree seedlings or shrubs beneath its canopy (USBR 2006a). Herbaceous cover is also very sparse. Scattered individual trees and shrubs may be interspersed through the blackberry scrub community. Himalayan blackberry generally establishes in gaps created by natural or human disturbances. Although Himalayan blackberry is an invasive species, this community does provide nesting habitat for some bird species and may be regulated under Section 1602 of the California Fish and Game Code when located within the bed, channel, or bank of a stream and may be subject to Corps jurisdiction under Section 404 of the CWA (USBR 2006a). The presence of Himalayan blackberry was found to positively influence yellow warbler abundance (RHJV 2004).

Great Valley Willow Scrub

Great Valley willow scrub is a deciduous broadleaved community with open to dense cover of shrubby willows. This community type may be dominated by a single species of willow or by a mixture of willow species. Dense stands have very little understory while more open stands have herbaceous understories, usually dominated by grasses characteristic of the annual grassland community. Characteristic plant species include sandbar willow, arroyo willow, shining willow, and California wild rose (USBR 2006a). Sandbar willow was found to positively influence the abundance of yellow-breasted chat (RHJV 2004). This community occupies point bars and narrow corridors along the active river channel that are repeatedly disturbed by high flows (USBR 2006a).

Great Valley Cottonwood Riparian Forest

Great Valley cottonwood riparian forest is a deciduous broadleaved forest community with a dense tree canopy dominated by Fremont cottonwood and often including a high abundance of black willow. This community also has a dense understory of seedlings, saplings, and sprouts of the canopy dominants and shade-tolerant species including boxelder and Oregon ash. Characteristic shrub species include California buttonbush and willows. Lianas such as California grape are typically present as well. This community occupies lower floodplain terraces that are flooded annually (USBR 2006a). It provides important breeding habitat for sensitive migratory birds including black-headed grosbeak, blue grosbeak, Swainson's hawk, yellow-breasted chat, and yellow-billed cuckoo (RHJV 2004). Fremont cottonwood has a positive influence on the abundance of black-headed grosbeak, while tree richness has a positive influence on black-headed grosbeak occurrence (RHJV 2004).

Great Valley Mixed Riparian Forest

Great Valley mixed riparian forest is a deciduous broadleaved forest community with a moderately dense to dense tree canopy that typically includes several species as codominates. Shrubs and lianas are also typically present. Mixed riparian forest is typically dominated by sycamore and valley oak with Fremont cottonwood, white alder, willow, catalpa, and Oregon ash also occurring frequently. Common shrub species in this community type include blue elderberry, California buttonbush, spicebush, and Himalayan blackberry. The herbaceous understory consists primarily of annual grasses and forbs similar to those found in the annual grassland communities but with a higher proportion of shade-tolerant species such as miner's lettuce, common bedstraw, bur-chervil, and meadow nemophila. At stream edges, the herbaceous understory of this community is characterized by hydrophytic species such as tall flatsedge, common tule, cattail, sedges, deergrass, and common monkeyflower. This community occupies intermediate flood terraces that are subject to occasional high-flow disturbance (USBR 2006a). It provides important breeding habitat for sensitive migratory birds including black-headed grosbeak, blue grosbeak, Swainson's hawk, yellow-breasted chat, and yellow-billed cuckoo (RHJV 2004). Shrub richness has a positive influence on the occurrence of common yellowthroat (RHJV 2004).

Great Valley Valley Oak Riparian Forest

Great Valley valley oak riparian forest is a deciduous broadleaved forest community with a closed canopy. This community type is similar to the Great Valley mixed riparian forest community described above but is clearly dominated by valley oak. Characteristic species include many of the same associates found in the Great Valley mixed riparian forest community type but tree and shrub associates are more widely scattered. This community occupies upper floodplain terraces where flooding is infrequent but soil moisture is high (USBR 2007). The presence of valley oak has a positive influence on yellow warbler and song sparrow abundance (RHJV 2004).

Wetland Vegetation Communities

Similar to riparian communities, much of the wetland habitat that once occurred in the Sacramento River Valley has been eliminated as a consequence of land use conversion to agriculture and urbanization. It is estimated that nearly 1.5 million acres of wetlands once occurred in the Central Valley. Today, about 123,000 acres remain. Wetland communities that are likely to occur in the primary study area between Shasta Dam and RBDD include freshwater marsh, freshwater seep, northern hardpan vernal pools, northern volcanic mudflow vernal pools, and other seasonal wetlands. Wetland plant communities in the primary study area may be subject to Corps jurisdiction under Section 404 of the CWA, if they meet the three wetland criteria or are contained within a jurisdictional water of the United States. Wetland communities that do not fall under Corps jurisdiction may still be regulated as waters of the State. In addition, wetland plant communities may be subject to CDFG regulation under Section 1602 of the Fish and Game Code if they are located within the bed, channel, or bank of a stream as defined below under “Regulatory Setting.” Vernal pools are considered sensitive because they provide potential habitat for Federally listed species including slender Orcutt grass, vernal pool fairy shrimp, and vernal pool tadpole shrimp; provide important ecological values and functions; and are likely considered waters of the State subject to jurisdiction of the Central Valley Regional Water Quality Control Board under the Porter-Cologne Act (USBR 2006a).

Freshwater Marsh

Freshwater marshes are herbaceous wetland plant communities that occur along rivers and lakes and are characterized by dense cover of emergent vegetation. Marshes are typically perennial wetlands, but may dry out for short periods of time. Characteristic freshwater marsh species include common tule, narrowleaf cattail, broadleaf cattail, common reed, tall flatsedge, common spikerush, and sedges (USBR 2007). The presence of sedges has a positive influence on the abundance of yellow-breasted chat and the occurrence of common yellowthroat (RHJV 2004).

Freshwater Seep

Freshwater seep is a wetland plant community characterized by dense cover of perennial herb species usually dominated by rushes, sedges, and grasses. Freshwater seep communities occur on sites with permanently moist or wet soils resulting from daylighting groundwater. Species commonly observed in freshwater seeps in the area include rushes, sedges, flatsedges, deergrass, cattail, bull thistle, blue-eyed grass, and willow (USBR 2007). The presence of sedges has a positive influence on the abundance of yellow-breasted chat and the occurrence of common yellowthroat (RHJV 2004).

Seasonal Wetland

Seasonal wetlands are ephemeral wetlands that pond or remain flooded for long periods during a portion of the year, generally the rainy winter season, then dry up, typically in spring. They often occur in shallow depressions on flood terraces that are occasionally to infrequently flooded. Seasonal wetlands are herbaceous communities typically characterized by species adapted for growth in both wet and dry conditions, and may contain considerable cover of upland species as well. Species commonly present in seasonal wetlands include tall flatsedge, dallisgrass, Bermuda grass, Italian ryegrass, Mediterranean barley, and curly dock. Seasonal wetlands differ from vernal pools in that they do not have a restrictive hardpan layer and are usually dominated by nonnative plant species, especially nonnative grasses. Vernal pools are typically distinguished by a unique host of native and endemic plant species adapted to the extreme conditions created by the cycles of inundation and drying. Seasonal wetlands differ from freshwater marshes and seeps in that they are not permanently flooded or saturated. The seasonal wetland community type is not included in the Holland or Sawyer and Keeler-Wolfe classification systems, but is recognized by Corps and may be subject to their jurisdiction under Section 404 of the CWA (USBR 2006a).

Non-Status Wildlife

The variety and availability of habitats along the Sacramento River between Shasta Dam and RBDD support a wide range of wildlife species. The composition, abundance, and distribution of wildlife are directly related to the accessibility of these habitats. These habitats support a wide variety of wildlife including a variety of waterfowl, raptors, and migratory and resident avian species, plus a variety of mammals, amphibians, and reptiles that inhabit both aquatic and upland habitats within the study area. Overall, however, the quantity and variety of wildlife species now inhabiting the area are fewer than before agricultural and residential development permanently removed much of the native and natural habitat. Many of the wildlife species are unable to adapt to other habitat types or altered habitat conditions and are, therefore, most susceptible to habitat loss and degradation. Species that depended on riparian woodland, oak woodland, marsh, and grassland habitats have declined. The region also supports a variety of exotic species, some of which are detrimental to survival of native species (USBR 2006a).

Existing native habitat, especially riparian corridors along the Sacramento River and associated sloughs and creeks, provides habitat for many native species. While riparian habitat is limited in this area, it supports the greatest abundance of wildlife, including a variety of avian species such as waterfowl and raptors; skunks; opossums; frogs, toads, and other amphibians; bats; coyote and fox; and garter snake and other reptiles. Riparian habitat provides shade, cover, and food supply to the immediate shoreline environment of large rivers, benefiting fish and wildlife species such as salmonids, river otter, beaver, heron, egret, and belted kingfisher (USBR 2006a). Riparian habitat along the Sacramento River is also important breeding habitat for sensitive migratory bird species including black-headed grosbeak, blue grosbeak, Swainson's hawk, yellow-breasted chat, and yellow-billed cuckoo (RHJV 2006a).

Grasslands and oak woodlands host a variety of seasonal game species and other wildlife, such as deer, jackrabbit, coyote, hawks and other raptors, gopher snake, pheasant, fox, raccoon, and California quail. The grasslands and foothills also support vernal pools and other seasonal wetlands that provide unique habitat for waterfowl, various small aquatic organisms, and breeding habitat for amphibians (USBR 2006a).

More arid chaparral habitat and scrub habitat support a variety of reptiles, weasel, feral pig, skunk, coyote, and larger mammals such as deer, bobcat, and mountain lion. Bird species that forage and nest in brush habitat within the area include wild turkey, pigeon, mourning dove, California thrasher, California towhee, and California quail (USBR 2006a).

Exotic wildlife species include the brown-headed cowbird, feral pig, wild turkey, pheasant, chukar, and bullfrog. Some of these exotic species have been detrimental to native vegetation and wildlife, such as the cowbird (which parasitizes the nests of other birds) and feral pigs (which uproot native vegetation and the nests of ground-nesting birds) (USBR 2006a).

Because animals are highly dependent on their choice habitats, changes in the quality and quantity of various habitat types have impacted area wildlife. The wildlife most affected in this area are those associated with riparian and grassland habitats, which have been highly impacted by land use, water resources development, and land management practices. Wildlife populations are also influenced by the age and density of the vegetation within the various habitat types. The general trend toward more dense underbrush in foothill habitats, due to fire suppression, has favored species that rely on dense vegetation for cover or foraging while negatively impacting raptors and other wildlife that require open areas for foraging. Conversion of grasslands to row crops has favored species that have adapted to the use of agricultural fields for foraging and species that can thrive in the altered landscape. Species that have adapted or thrived in the modified human environment include coyote, raccoon, and various late successional species. The introduction of non-native species has had both positive and negative effects on wildlife in riparian and grassland areas (USBR 2007).

Migratory and Focal Bird Species along the Sacramento River

CalPIF and RHJV published Bird Conservation Plans for the major habitat types in the state of California (CalPIF 2000, CalPIF 2002a, CalPIF 2002b, CalPIF 2004, RHJV 2004). The Bird Conservation Plans contain a list of focal bird species to be targeted for conservation for each major habitat type. Discussed below are the focal bird species that occur within oak woodland and riparian habitat within the primary Sacramento River study area.

<u>Oak Woodland</u>

In the Oak Woodland Bird Conservation Plan (CalPIF 2002a), CalPIF focuses on the following bird species for conservation associated with oak woodland habitat within the primary study area along the Sacramento River: acorn woodpecker, blue-gray gnatcatcher, lark sparrow, Nuttall’s woodpecker, oak titmouse, western bluebird, western scrub-jay, and yellow-billed magpie. But conservation recommendations, if implemented, should benefit many oak woodland associated species.

Riparian

In the Riparian Bird Conservation Plan (RHJV 2004), CalPIF and RHJV focus on the following bird species for conservation associated with riparian habitat within the primary study area along the Sacramento River: bank swallow, black-headed grosbeak, blue grosbeak, common yellowthroat, song sparrow, Swainson's hawk, tree swallow, tricolored blackbird, yellow-billed cuckoo, yellow-breasted chat, and yellow warbler. But conservation recommendations, if implemented, should benefit many montane riparian associated species. Special-status bird species that are known to occur in riparian habitat along the Sacramento River include western yellow-billed cuckoo, California yellow warbler, yellow-breasted-chat, tricolored blackbird, bank swallow, and Swainson's hawk. Each of these special-status bird species are discussed in Appendix E of this report. Species-specific conservation measures for CALFED MSCS bird species are included in Appendix D of this report.

Special-Status Floral Species along the Sacramento River

There are six special-status plant species identified as having potential to occur near Shasta Dam and in the area along the Sacramento River between Shasta Dam and RBDD. These species are mountain lady's slipper, adobe lily, Red Bluff dwarf rush, dubious pea, Ahart's paronychia, and oval-leaved viburnum. Slender Orcutt grass, a species that is State and federally listed as endangered, could also occur in the primary study area along the Sacramento River between Shasta Dam and RBDD if suitable vernal pool habitat is present. Bogg's Lake hedge hyssop, a species that is State listed as endangered, could potentially occur in freshwater marsh habitat or vernal pools in the primary study area. Fox sedge, silky cryptantha, dwarf downingia, four angled spikerush, Ahart's dwarf rush, and Greene's legenere are additional CNPS List 1B or 2 species that have potential to occur in the primary study area. Henderson's bent grass, a CNPS List 3 species, could also occur in the primary study area if suitable vernally mesic habitat, such as vernal pools, is present.

Special-status Wildlife Species along the Sacramento River

Table 8 above lists special-status wildlife species that have the potential to occur near Shasta Dam and in the area along the Sacramento River between Shasta Dam and RBDD.

Extended Study Area: Aquatic Communities and Associated Special-Status Species

The extended study area includes all of the components of the CVP/SWP system that would be affected by the proposed changes in the operation of Shasta Dam. Therefore, aquatic habitat occurring within the extended study area includes the Sacramento River downstream from the RBDD to the Delta, Oroville Reservoir and the lower Feather River, Folsom Reservoir the lower American River Basin, the Delta, and the lower San Joaquin River.

Sacramento River

The Sacramento River is an important migration corridor for anadromous fishes moving between the Pacific Ocean or the Delta and upper river and tributary spawning and rearing habitats. Over 30 species of fish are known to use the Sacramento River. Of these, a number of both native and introduced species are anadromous. Anadromous species include Chinook salmon, steelhead, green and white sturgeon, striped bass and American shad. The lower Sacramento River is generally defined as that portion of the river from Princeton to the Delta, at approximately Chipps Island (near Pittsburg). The lower Sacramento River is predominantly channelized, leveed and bordered by agricultural lands. Aquatic habitat in the lower Sacramento River is characterized primarily by slow-water glides and pools, depositional in nature, reduced water clarity and channel habitat diversity, relative to the upper portion of the river.

Many of the fish species utilizing the upper Sacramento River also use the lower river to some degree, even if only as a migratory pathway to and from upstream spawning and rearing grounds. For example, adult Chinook salmon and steelhead primarily use the lower Sacramento River as an immigration route to upstream spawning habitats and an emigration route to the Delta. The lower river is also used by other fish species (*e.g.*, Sacramento splittail and striped bass) that make little to no use of the upper river (upstream of RM 163). Overall, fish species composition in the lower portion of the Sacramento River is quite similar to that of the upper Sacramento River and includes resident and anadromous cold- and warmwater species. Many fish species that spawn in the Sacramento River and its tributaries depend on river flows to carry their larval and juvenile life stages to downstream nursery habitats. Native and introduced warmwater fish species primarily use the lower river for spawning and rearing, with juvenile anadromous fish species also using the lower river and nonnatal tributaries, to some degree, for rearing.

An important component of aquatic habitat throughout the Sacramento River is referred to as SRA cover. SRA cover consists of the portion of the riparian community that directly overhangs or is submerged in the river. SRA cover provides high-value feeding and resting areas, as well as escape cover for juvenile anadromous salmonids and resident fishes. SRA cover also can provide some degree of local temperature moderation and refugia during summer months due to the shading it provides to nearshore habitats. The importance of SRA cover to Chinook salmon was demonstrated in studies conducted by the Service (DeHaven 1989). In early summer, juvenile Chinook salmon were found exclusively in areas of SRA cover, and none were found in nearby rip-rapped areas (DeHaven 1989). Other studies have similarly found a decrease in the density of juvenile salmon along rip-rapped areas of the Sacramento River compared to natural bank areas (*e.g.*, Michny 1988, Schaffter *et al.* 1983). Streambanks with riprap have fewer undercut banks, less low-overhead cover and are less likely than natural stream banks to contribute large woody debris to the stream (Schmetterling *et al.* 2001, USFWS 2004b). Snorkeling surveys of juvenile Chinook salmon in the middle Sacramento River (RM 180 – 230 (a few miles downstream from Ord Ferry up to the Elder Creek)) suggest that the lack of suitable juvenile rearing habitat may be the most limiting factor for anadromous fish survival; less than 1 percent of the middle Sacramento River is suitable juvenile rearing habitat (Cannon 2007).

Yolo Bypass

The 61-km long Yolo Bypass is a 24,000-hectare leveed floodplain in the lower Sacramento River that empties into the Delta (Sommer *et al.* 2001b). The Yolo Bypass floods seasonally in winter and spring in about 60 percent of years (Sommer *et al.* 2001b). The bypass is able to convey up to 80 percent (14,000 m^3 per second (494,405 cfs)) of the flow of the Sacramento River basin during high water events (Sommer *et al.* 2001b). During a typical flood event, water spills into the Yolo Bypass via Fremont Weir when Sacramento River flows surpass about 2000 m^3 per second (70,629 cfs) (Sommer *et al.* 2001b). At higher levels of Sacramento River flow (*e.g.*, >5000 m^3 per second (176,573 cfs)), the Sacramento Weir is also frequently operated. The mean depth of the bypass is less than 2 m, except during high flow events (Sommer *et al.* 2001b). Agricultural lands and seasonal and permanent wetlands within the bypass provide key habitat for waterfowl migrating through the Pacific Flyway. One-third of the bypass is natural vegetation, including riparian habitat, upland habitat, emergent marsh, and permanent ponds (Sommer *et al.* 2001b). The bypass seasonally supports 42 fish species, 15 of which are native (Sommer *et al.* 2001a,b).

Seasonal long-duration inundation of floodplain habitat in the Yolo Bypass has been shown to be highly beneficial for outmigration, survival and growth of Sacramento basin Chinook salmon, spawning and recruitment of Sacramento splittail, and production and export of phyto- and zooplankton to the north Delta (Sommer *et al.* 1997; Sommer *et al.* 2001a,b). A study of juvenile fall-run Chinook salmon attributed observed higher growth rates in the Yolo Bypass compared to the Sacramento River to higher densities of dipteran insect prey associated with woody debris in the Yolo Bypass (Sommer *et al.* 2001b). At this time, there is no objective for flow through and discharges from the Yolo Bypass into the Delta.

Sacramento – San Joaquin Delta

San Francisco Bay (Bay) and the Delta make up the largest estuary on the west coast (USEPA 1992). The Delta, the most upstream portion of the Bay-Delta, is a triangle-shaped area composed of islands, river channels, and sloughs at the confluence of the Sacramento and San Joaquin rivers. The Bay-Delta estuary provides habitat for a diverse assemblage of fish and macroinvertebrates. Many of the fish and macroinvertebrate species inhabit the estuary year-round, while other species inhabit the system on a seasonal basis as a migratory corridor between upstream freshwater riverine habitat and coastal marine waters, as seasonal foraging habitat, or for reproduction and juvenile rearing.

Migratory (*e.g.*, anadromous) fish species which inhabit the Bay-Delta system and its tributaries include, but are not limited to, white sturgeon, green sturgeon, Chinook salmon (including fall-run, spring-run, winter-run, and late fall-run), steelhead, American shad, Pacific lamprey and river lamprey (Moyle 2002). The Bay-Delta and tributaries also support a diverse community of resident fish which includes, but is not limited to, Sacramento sucker, prickly and riffle sculpin, California roach, hardhead, hitch, Sacramento blackfish, Sacramento pikeminnow, speckled dace, Sacramento splittail, tule perch, inland silverside, black crappie, bluegill, green sunfish, largemouth bass, smallmouth bass, white crappie, threadfin shad, carp, golden shiner, black and brown bullhead, channel catfish, white catfish, and a variety of other species which inhabit the more estuarine and freshwater portions of the Bay-Delta system (Moyle 2002).

Many factors have contributed to the decline of fish species within the Delta (Moyle *et al.* 1995), including changes in hydrologic patterns resulting from water project operations, loss of habitat, contaminant input, entrainment in diversions, and introduction of non-native species. The Delta is a network of channels through which water, nutrients, and aquatic food resources are moved and mixed by tidal action. Pumps and siphons divert water for Delta irrigation and municipal and industrial use or into CVP and SWP canals. River inflow, Delta Cross Channel operations, and diversions (including agricultural and municipal diversions and export pumping) affect Delta species through changes in habitat conditions (*e.g.*, salinity intrusion), and mortality attributable to entrainment in diversions.

Seasonal and interannual variability in hydrologic conditions, including the magnitude of flows into the Bay-Delta estuary from the Sacramento and San Joaquin rivers and other tributaries and the outflow from the Delta into San Francisco Bay, have been identified as important factors affecting habitat quality and availability, and abundance for a number of fish and invertebrate species within the Bay-Delta estuary. Flows within the Bay-Delta system may affect larval and juvenile transport and dispersal, water temperatures (primarily within the upstream tributaries), dissolved oxygen concentrations (e.g., during the fall within the lower San Joaquin River), and salinity gradients within the estuary. The seasonal timing and geographic location of salinity gradients are thought to be important factors affecting habitat quality and availability for a number of species (Baxter *et al.* 1999). Operation of upstream storage impoundments, in combination with natural hydrologic conditions, affects seasonal patterns in the distribution of salinity within the system. Water project operations, for example, may result in a reduction in Delta inflows during the late winter and spring with an increase in Delta inflows, when compared to historical conditions, during the summer months. Objectives have been established for the location of salinity gradients during the late winter and spring to support estuarine habitat for a number of species (X2 location), in addition to other salinity criteria for municipal, agricultural, and wetland benefits. Although a number of studies have focused on the effects of variation in salinity gradients as a factor affecting estuarine habitat during the late winter and spring (Kimmerer 2002), very little information exists on the effects of increased inflows into the Delta during summer months and the resulting changes in salinity conditions (e.g., reduced salinity when compared to historical conditions) on the abundance, growth, survival, and distribution of various fish and macroinvertebrates inhabiting the Bay-Delta system.

Lower American River

The American River drains a watershed of approximately 1,895 square miles (USBR 2006b), and is a major tributary to the Sacramento River. The American River has historically provided over 125 miles of riverine habitat to anadromous and resident fishes. Presently, use of the American River by anadromous fish is limited to the 23 miles of river downstream of Nimbus Dam (the lower American River).

Special-Status Aquatic Species of the Extended Study Area

Juvenile and adult Chinook salmon, steelhead, and green sturgeon use the Sacramento River and Sacramento-San Joaquin Delta as a migration corridor. Juvenile Chinook salmon and steelhead also use the Sacramento River, Delta, and Yolo Bypass for rearing (Sommer *et al.* 2001a,b). The lack of SRA and large woody debris for cover in this reach of the Sacramento River is thought to be a limiting factor for the survival of juvenile salmonids (Cannon 2007). Delta smelt, Sacramento splittail, and longfin smelt depend on the Delta estuarine ecosystem. Juvenile Sacramento splittail prefer shallow-water habitat with emergent vegetation during rearing (Meng and Moyle 1995). Sommer *et al.* (2002) report juvenile splittail are more abundant in the Yolo Bypass floodplain in the shallowest areas of the wetland with emergent vegetation. The life-history and species account for the special-status aquatic species are included in Appendix E of this report.

Extended Study Area: Upland Communities and Associated Special-Status Species

Increasing water supply reliability with the SLWRI is likely to result in changes in land use throughout the CVP/SWP water service areas. Therefore, the extended study area for the SLWRI includes all of the water service areas for the CVP/SWP. The water service areas for the CVP/SWP include agricultural lands M&I users throughout Northern and Southern California. Increasing water supply reliability with the SLWRI will likely result in the further conversion of rangelands and natural lands into urban sprawl and cultivated agriculture fields. Increased water supply reliability also will likely result in the conversion of agricultural lands into urban sprawl or into more intensively cultivated lands. The loss of rangeland, natural lands, and agricultural land will adversely affect common and special-status wildlife species throughout the Central Valley and Southern California. There is not enough information at this time to analyze the extent to which land use patterns would change as a result of the SLWRI. Section 7 consultation under ESA will address the impacts of the SLWRI to federally listed species within the CVP-SWP water service areas.

FUTURE CONDITIONS WITHOUT PROJECT

The No Action Alternative is defined as the most likely future condition that could be expected to occur in the absence of the SLWRI. Hydrological and salmonid population modeling for the SLWRI use the No Action Alternative as a surrogate for the "Future Conditions Without Project." Therefore, in this report, the No Action Alternative is used to refer to the "Future Conditions Without Project."

Reclamation defines the No Action Alternative in the Plan Formulation Report (PFR) (USBR 2007) as "the Federal Government would take no additional action to implement a specific plan to help increase anadromous fish survival in the upper Sacramento River, address, water supply reliability problems, needs, and opportunities in the Central Valley of California, or help restore ecosystem values, increase hydropower generation, or increase recreation opportunities at Shasta Lake." The Service, however, believes that without the SLWRI the Federal Government *would* take additional actions to help increase anadromous fish survival in the upper Sacramento River as identified in the CVPIA, the State Water Resources Control Board (SWRCB) Order 90-5 (which specifies terms and conditions for the maintenance of water quality in the Sacramento River below Shasta Dam, Keswick Dam, and the Spring Creek Power Plant), the 1993 biological opinion for winter-run Chinook salmon (NOAA Fisheries 1993), and Senate Bill 1086. This future condition includes actions found in the AFRP Restoration Plan (USFWS 2001), developed to comply with Section 3406(b)(1) of the CVPIA.

The AFRP Restoration Plan identifies several high priority actions for increasing anadromous fish survival in the upper Sacramento River including the following: (1) implementing a river flow regulation plan that balances carryover storage needs with instream flow; (2) maintaining water temperatures at or below 56^{o}F from Keswick Dam to Bend Bridge; (3) creating a meander belt from Keswick Dam to Colusa to recruit gravel and large woody debris, to moderate temperatures and to enhance nutrient input; (4) restoring and replenishing spawning gravel, where appropriate, in the Sacramento River; (5) evaluate opportunities to incorporate flows to restore riparian vegetation from Keswick Dam to Verona that are consistent with the overall river regulation plan; and (6) identify opportunities for restoring riparian forests in channelized section of the upper mainstem Sacramento River that are appropriate with flood control and other water management constraints.

For the Keswick Dam – RBDD reach, SRCAF, as supported by Senate Bill 1086, recognizes the following restoration priorities: (1) protect physical processes where still intact; (2) allow riparian forest to reach maturity; (3) restore physical and successional processes; and (4) conduct reforestation activities. Therefore, in the likely future condition without the SLWRI, some restoration of the Sacramento River is to be expected in line with the goals and mandates of the CVPIA and SRCAF.

Therefore, based on goals and mandates from the CVPIA, the SWRCB Order 90-5, the 1993 biological opinion for winter-run Chinook salmon as outlined in the AFRP Recovery Plan, and Senate Bill 1086, it can reasonably be assumed that in the "likely future conditions without the Project" the Federal Government would still take actions to increase anadromous fish survival and restore riparian habitat in the upper Sacramento River. Current and foreseeable restoration projects include the Trinity River Restoration Program (TRRP), CALFED Ecosystem Restoration Program (ERP), and CVPIA AFRP (Koch *in litt.* 2006).

Through the significant efforts of Federal and State wildlife agencies, populations of special-status species in the riverine and nearby areas are estimated to generally remain as under existing conditions or potentially increase. Although increases in anadromous and resident fish populations in the Sacramento River could continue through implementation of projects such as the Battle Creek Salmon and Steelhead Restoration Project, some degradation would likely occur through actions that reduce Sacramento River flows or elevate water temperatures. Accordingly, populations of anadromous fish are expected to remain generally similar to existing conditions.

Table 9 illustrates the limiting factors in the upper main stem Sacramento River as per the AFRP Working Paper (USFWS 1995b). Some of the identified solutions developed by AFRP have been implemented (e.g., correcting fish passage problems at the Anderson ACID and GCID Dam, and maintaining water temperatures in the river) but many are still relevant (Koch *in litt.* 2006). Therefore, in the likely future condition without the SLWRI, some of the limiting factors in Table 9 would continue while others would be addressed through CVPIA and the AFRP.

<u>Aquatic Species</u>

In the No Action Alternative, reservoir operations would not change, nor would Sacramento River flow regimes or water temperatures. Therefore, no additional impacts would occur to fisheries resources (both anadromous and resident) beyond what currently occurs (*e.g.*, unsuitable water temperatures for some spawning fish, continued blockage of fish passage, continued blockage of coarse sediments necessary for spawning habitat). However, restoration projects identified and/or required through CVPIA, AFRP, and Senate Bill 1086 are expected to improve conditions for anadromous fish in the Sacramento River and tributaries.

Anadromous Fish

Salmod simulates the base- and Project-related mortality of eggs, fry, pre-smolts, and immature smolts for each of the four runs of Chinook salmon in the Sacramento River between Keswick Dam and RBDD for water years 1922 - 2002. The different types of mortality were defined previously in the “Salmod” section. A more detailed analysis of the sources of mortality of eggs, fry, pre-smolts, and immature smolts for each of the four runs of Chinook salmon in the Salmod output for No Action and the SLWRI alternatives is provided in Appendix B of this report. Salmod output is analyzed for simulations using current population levels (*i.e.*, 1999 – 2006 population average (CDFG 2007b) and predicted future population recovery levels (*i.e.*, AFRP population goals) for the mainstem Sacramento River between Keswick Dam and the RBDD. In summary, the Salmod modeling results show that during the water years 1922 – 2002 simulation period, thermal mortality of winter-, fall-, and late fall-run Chinook salmon in the No Action Alternative was primarily restricted to a few dry and critically dry water years representing less than 10 percent of the simulation period. Thermal mortality to spring-run Chinook salmon eggs occurred during 40 percent of the simulation period.

Table 9. Upper Main Stem Sacramento River Limiting Factors as per the Anadromous Fish Restoration Program (AFRP) Working Paper (USFWS 1995b)

Limiting Factors	Potential Solutions
Instream Flows	1. Regulate CVP flow releases to provide adequate spawning and rearing habitat. 2. Avoid flow fluctuations to avert dewatering redds or stranding or isolating adults and juveniles. 3. Consider all effects of flow on ecosystem.
Water Temperatures	Maintain water temperatures at or below 56°F to at least Bend Bridge to Keswick Dam except in extreme water years.
Passage at artificial impairments is inadequate	1. Correct migration problems at RBDD. 2. Correct fish passage and other problems at the 3. ACID's diversion dam. 4. Avoid entrapment of adults at Keswick Dam stilling 5. Basin. 6. Correct unscreened pump diversions. 7. Correct problems at the GCID water diversions.
Contaminants	Remedy water quality problems associated with Iron Mountain Mine and other toxic discharges.
Effects of hatchery stocks on natural spawning stocks is unknown	1. Evaluate competitive displacement between hatchery and natural stocks. 2. Evaluate displacement of natural stocks by hatchery stocks. 3. Maintain genetic diversity in hatchery stocks. 4. Evaluate disease relationships between hatchery and natural stocks.
Loss of riparian forests	Restore and preserve riparian forests.

Winter-run Chinook Salmon

Figures 1A and 1B illustrate the relative sources of mortality of winter-run Chinook salmon eggs based on simulations of current population levels and AFRP population goals, respectively. The thermal mortality rate of winter-run Chinook salmon eggs, fry, and pre-smolts in No Action exceeded 2 percent during only a few dry and critically dry water years representing 9 percent of the years simulated. Simulations based on current population levels show other than base mortality the flushing and dewatering of redds was the primary source of mortality of winter-run eggs with a mortality rate of 2.0 – 9.3 percent during 42 percent of the years simulated. Simulations based on AFRP population levels show that superimposition surpassed the flushing and dewatering of redds as the primary source of mortality of winter-run eggs with a mortality rate of 6.4 – 30.5 percent throughout the simulation period. Mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) other than base mortality was the primary source of mortality of winter-run fry. Mortality due to entrainment in unscreened water diversions (other than base mortality) was the primary source of mortality to winter-run pre-smolts and immature smolts. However, Salmod modeling likely underestimates the mortality of winter-run eggs, fry, pre-smolts and immature smolts: (1) due to the inability of Salmod to model resource competition among the four runs of Chinook salmon and steelhead; and (2) by limiting the simulation to areas upstream of the RBDD where mortality rates are considerably lower than further downstream. Graphs and a more detailed discussion of the sources of mortality of winter-run Chinook salmon are provided in Appendix B of this report.

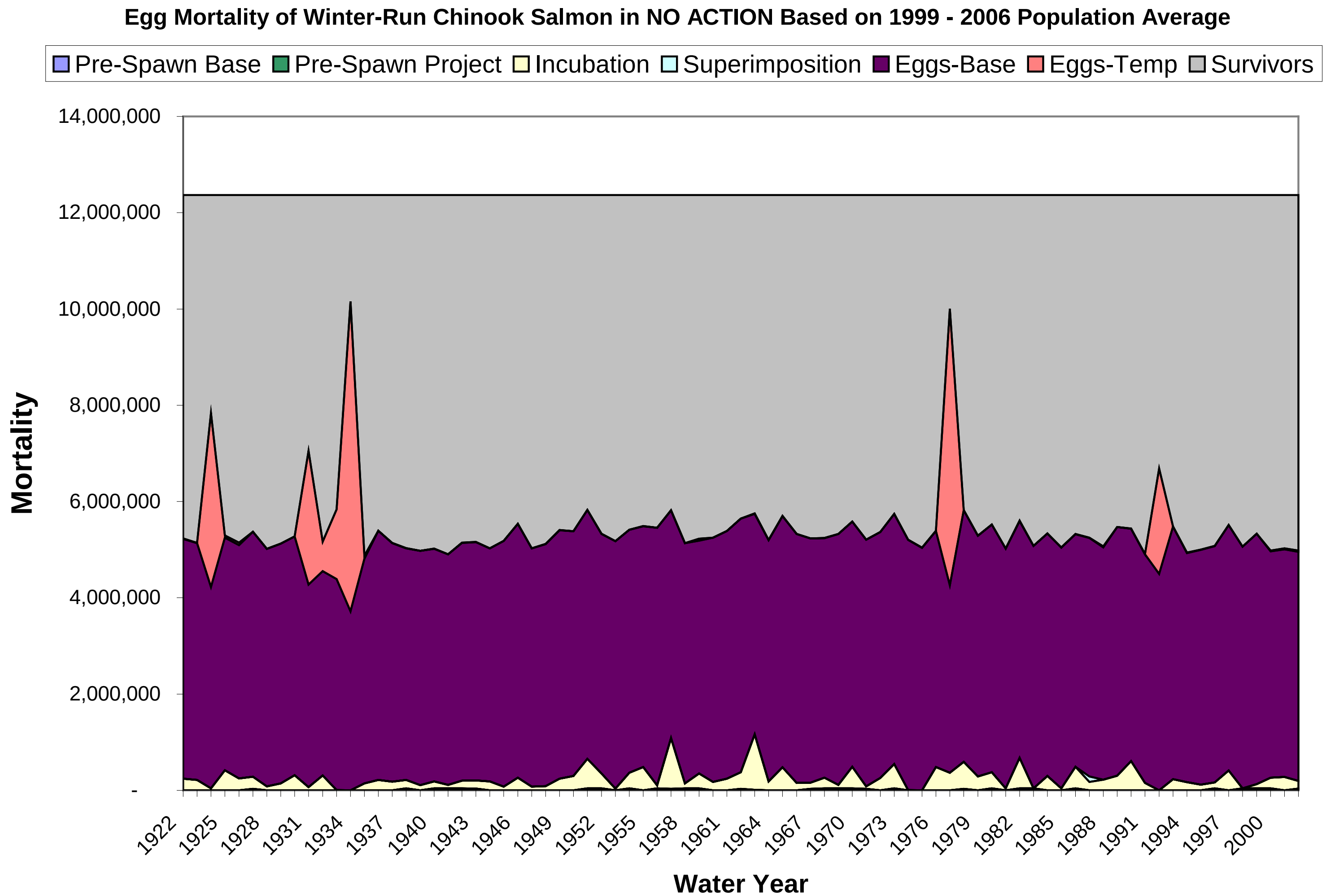

Figure 1A. Source of mortality of winter-run Chinook salmon eggs in NO ACTION based on the 1999 – 2006 population average.

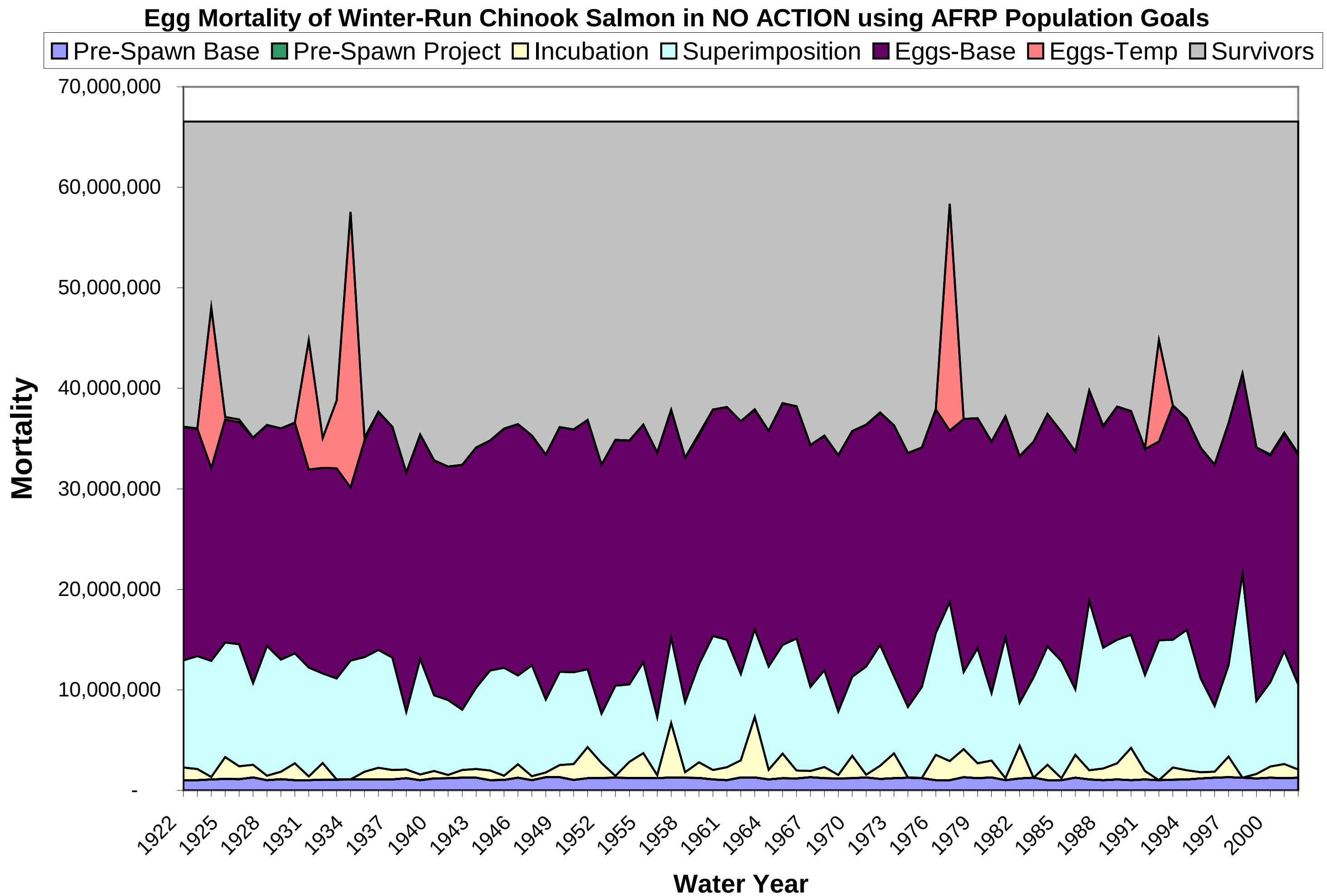

Figure 1B. Source of mortality of winter-run Chinook salmon eggs in NO ACTION based on AFRP population goals

Spring-run Chinook Salmon

Figures 2A and 2B illustrate the relative sources of mortality of spring-run Chinook salmon eggs based on simulations of current population levels and AFRP population goals, respectively. The thermal mortality rate of spring-run Chinook salmon eggs exceeded 2 percent during 38 percent of the years simulated in No Action. Simulations based on current population levels showed base mortality was the only significant source of mortality of spring-run fry. However, simulations based on AFRP population levels show the mortality rate to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) ranging from 8 – 18 percent during 91 percent of the years simulated. Mortality due to entrainment in unscreened water diversions was the primary source of mortality to spring-run pre-smolts with a mortality rate of 3 – 10 percent for current population levels and 5 – 10 percent for AFRP population levels throughout the simulation period. Salmod modeling shows no significant mortality to spring-run immature smolts. However, Salmod modeling likely underestimates the mortality of spring-run eggs, fry, pre-smolts and immature smolts: (1) due to the inability of Salmod to model resource competition among the four runs of Chinook salmon and steelhead; and (2) by limiting the simulation to areas upstream of the RBDD where mortality rates are considerably lower than further downstream. Graphs and a more detailed discussion of the sources of mortality of spring-run Chinook salmon are provided in Appendix B of this report.

Fall-run Chinook Salmon

Figures 3A and 3B illustrate the relative sources of mortality of fall-run Chinook salmon eggs based on simulations of current population levels and AFRP population goals, respectively. The thermal mortality rate of fall-run Chinook salmon eggs exceeded 2 percent during only a few dry and critically dry water years representing 10 percent of the years simulated in No Action. Mortality due to superimposition and the flushing and dewatering of redds were the primary sources of mortality to fall-run eggs. Mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the primary source of mortality for fall-run fry with a mortality rate of 7 – 37 percent based on current population levels and 6 – 50 percent based on AFRP population levels. Mortality due to entrainment in unscreened water diversions was the primary source of mortality to fall-run pre-smolts with a mortality rate of 2 – 5 percent throughout the simulation period. Salmod modeling shows no significant mortality to fall-run immature smolts. However, Salmod modeling likely underestimates the mortality of fall-run eggs, fry, pre-smolts and immature smolts: (1) due to the inability of Salmod to model resource competition among the four runs of Chinook salmon and steelhead; and (2) by limiting the simulation to areas upstream of the RBDD where mortality rates are considerably lower than further downstream. Graphs and a more detailed discussion of the sources of mortality of fall-run Chinook salmon are provided in Appendix B of this report.

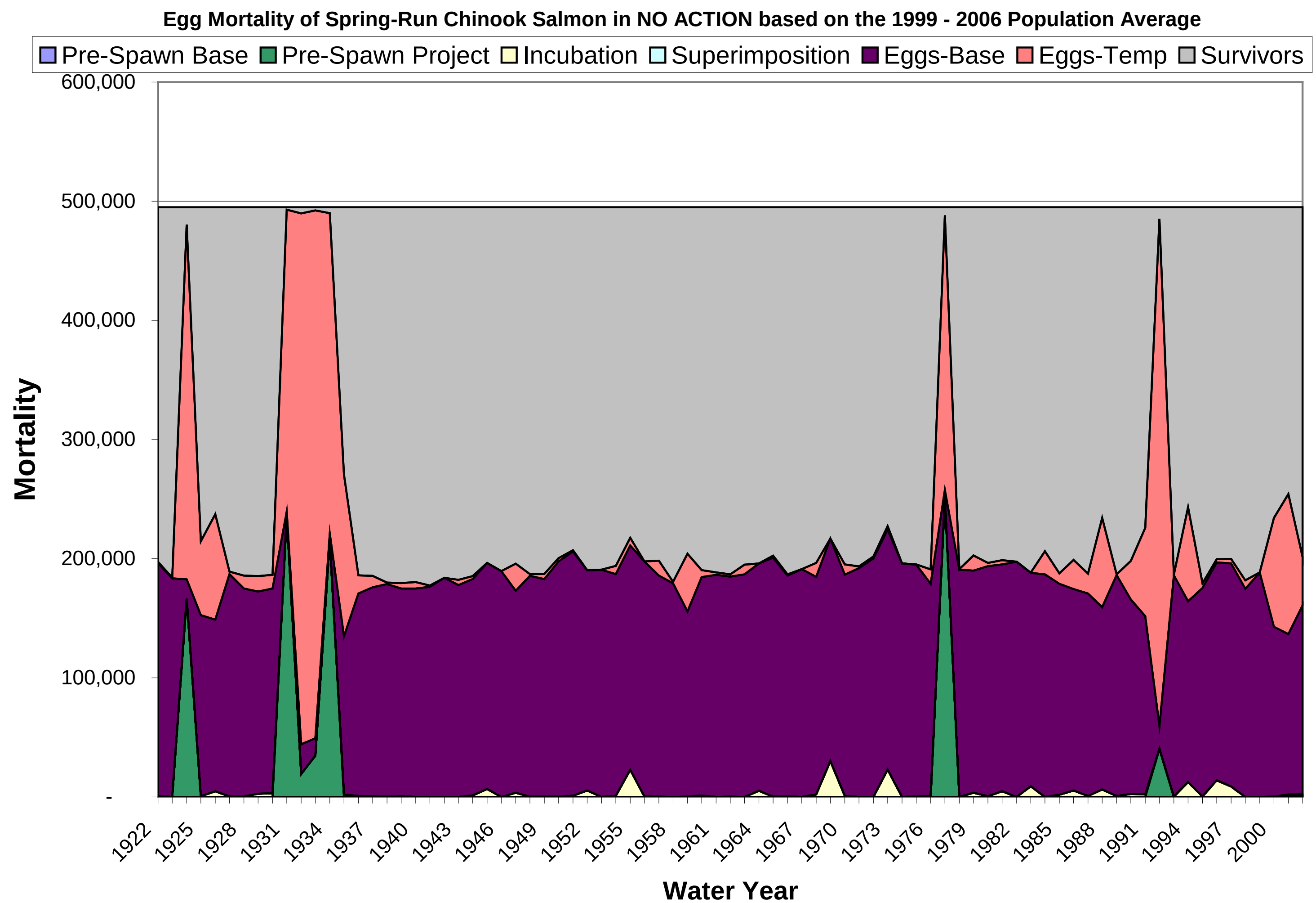

Figure 2A. Source of mortality of spring-run Chinook salmon eggs in NO ACTION based on the 1999 – 2006 population average.

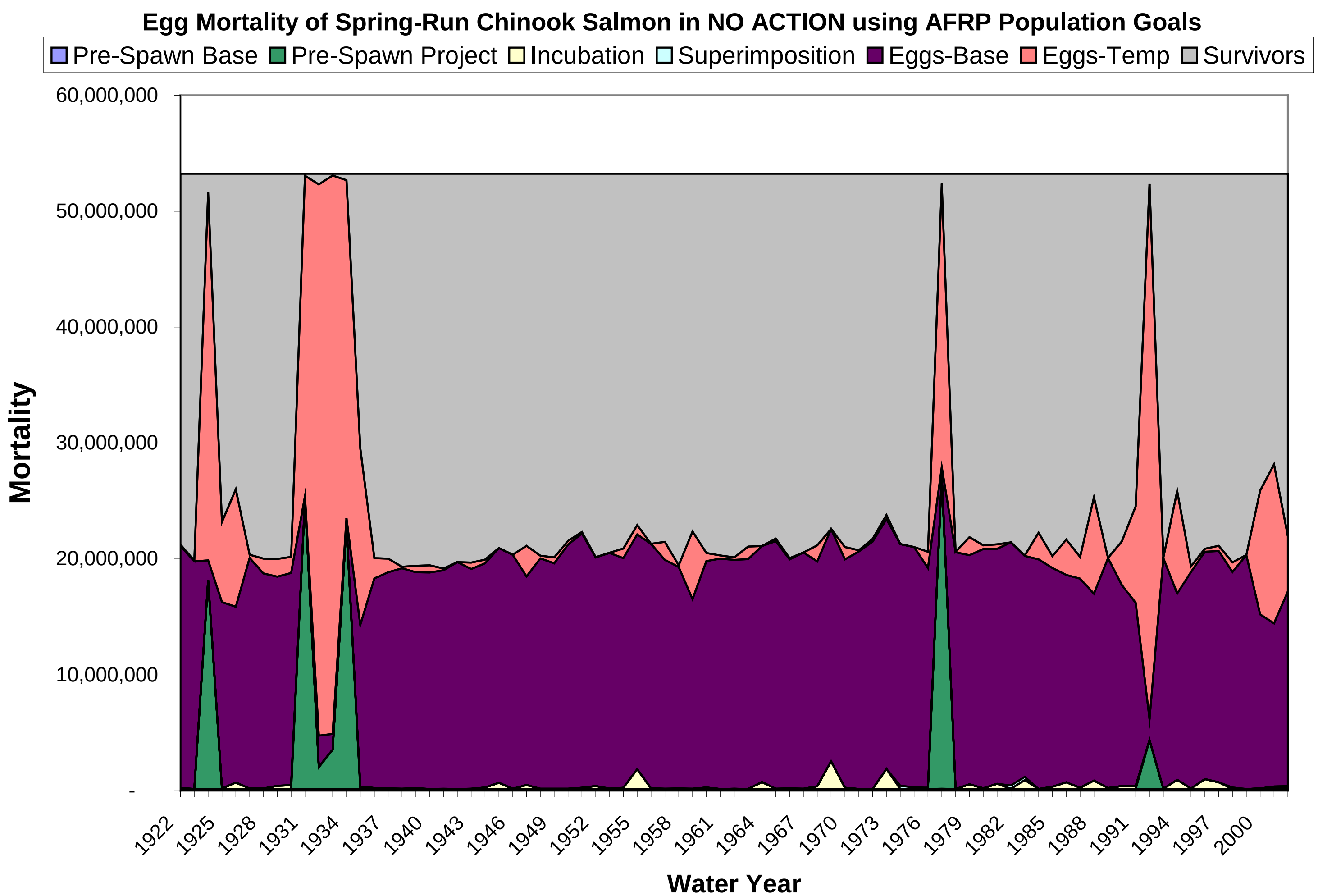

Figure 2B. Source of mortality of spring-run Chinook salmon eggs in NO ACTION based on the AFRP population goals.

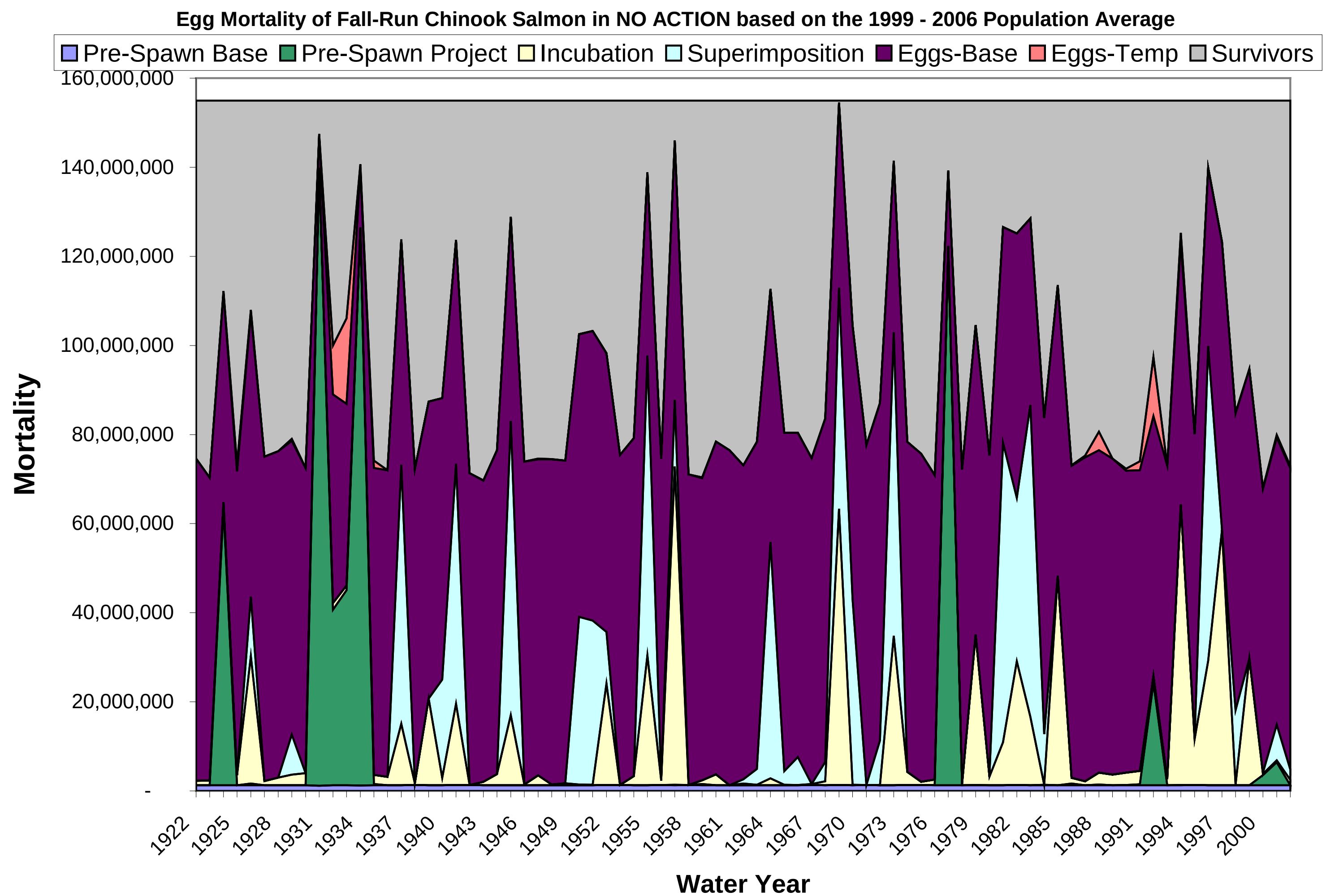

Figure 3A. Source of mortality of fall-run Chinook salmon eggs in NO ACTION based on the 1999 – 2006 population average.

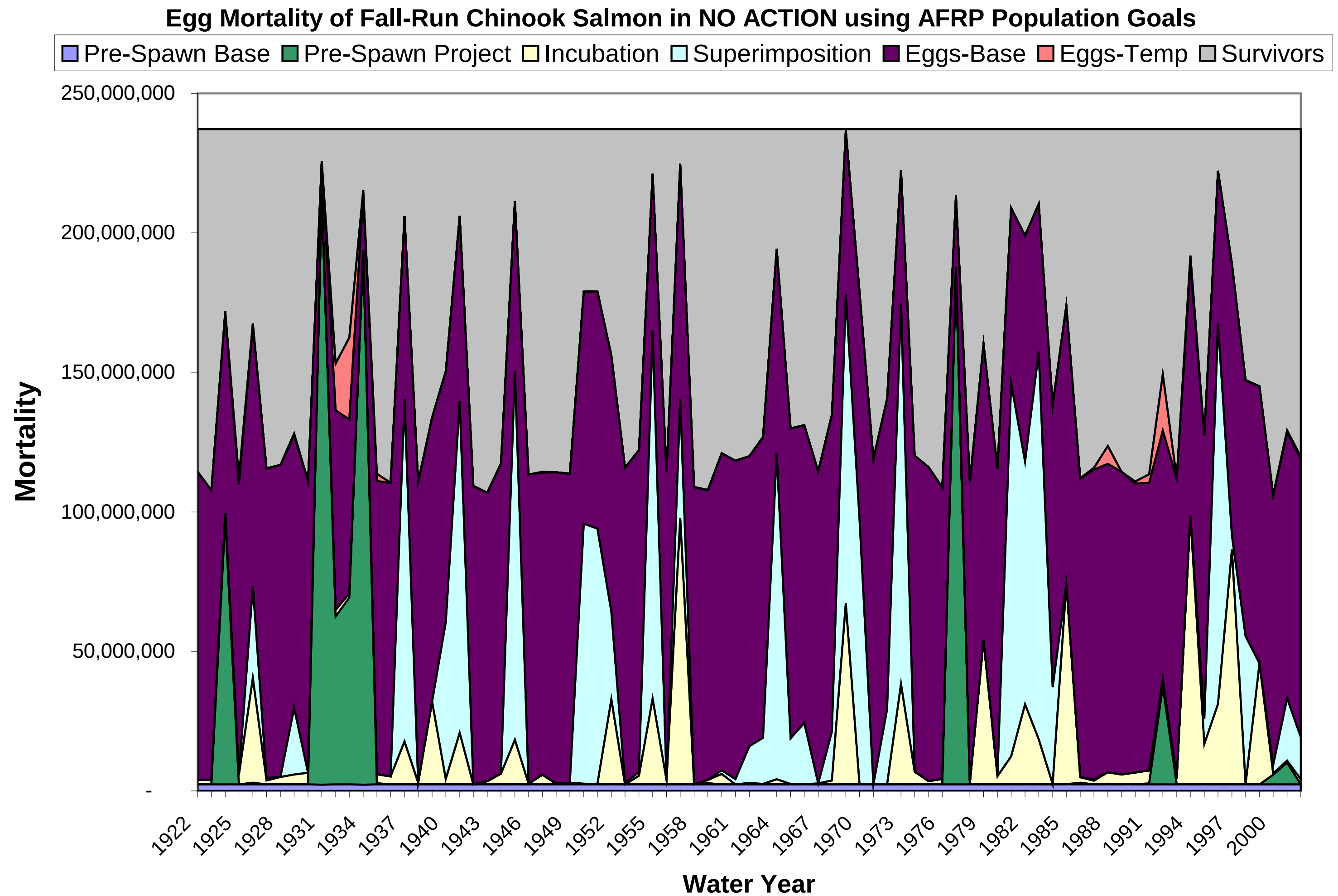

Figure 3B. Source of mortality of fall-run Chinook salmon eggs in NO ACTION based on the AFRP population goals.

Late Fall-run Chinook Salmon

Figures 4A and 4B illustrate the relative sources of mortality of winter-run Chinook salmon eggs based on simulations of current population levels and AFRP population goals, respectively. Mortality due to superimposition and the flushing or dewatering of redds were the primary sources of mortality for late fall-run Chinook salmon eggs in No Action. The thermal mortality rate of late fall-run eggs never exceeded 0.8 percent. Mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the primary source of mortality for late fall-run fry with a mortality rate of 4 - 26 percent based on current population levels and 4 - 42 percent based on AFRP population levels. The thermal mortality of late fall-run pre-smolts and immature smolts exceeded 2 percent during 9 percent of the years simulated. Mortality due to entrainment in unscreened water diversions was the primary source of mortality to late fall-run pre-smolts and immature smolts with a mortality rate ranging from 0.5 – 4.4 percent. Salmod modeling shows no significant mortality to late fall-run immature smolts. However, Salmod modeling likely underestimates the mortality of late fall-run eggs, fry, pre-smolts and immature smolts: (1) due to the inability of Salmod to model resource competition among the four runs of Chinook salmon and steelhead; and (2) by limiting the simulation to areas upstream of the RBDD where mortality rates are considerably lower than further downstream. Graphs and a more detailed discussion of the sources of mortality of late fall-run Chinook salmon are provided in Appendix B of this report.

Terrestrial/Wetland Vegetation and Wildlife

Vegetation

The No Action Alternative would not result in any changes to existing facilities or to the operation of reservoirs. As a result, there would be no temporary disturbance, altered structure and species composition, or loss of common plant, oak, or wetland communities; and no temporary disturbance or loss of riparian communities. There would, however, continue to be alteration of the structure and species composition of riparian vegetation resulting from continued operation of Shasta Dam. Prior to the construction of Shasta Dam, flow volume would decrease gradually during the period of cottonwood and willow seed dispersal. In many years, this flow pattern would facilitate establishment of these early successional species along the Sacramento River throughout the primary study area. Similar conditions exist in portions of the extended study area. Operation of Shasta Dam has increased flow volumes in mid-spring to early summer.

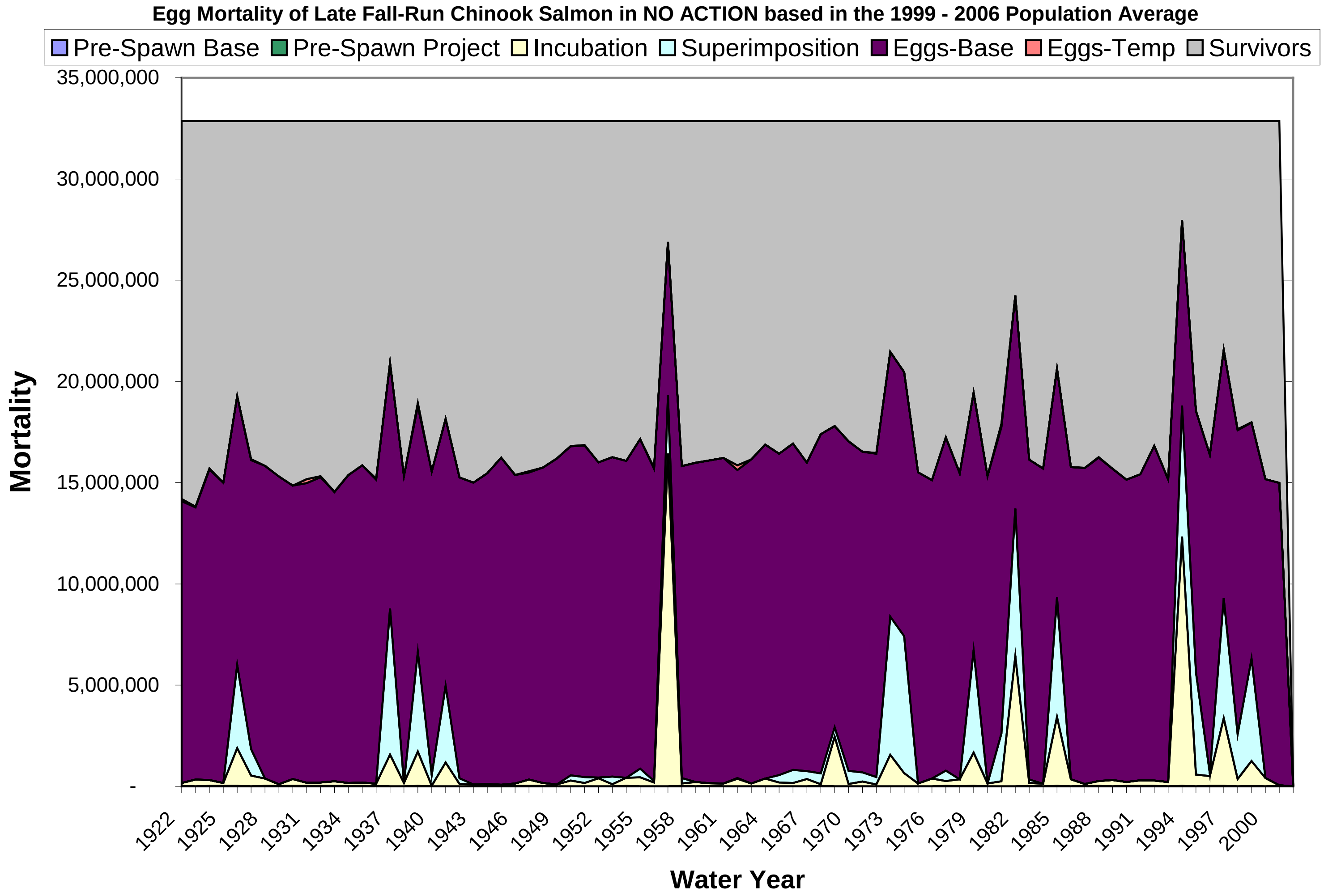

Figure 4A. Source of mortality of late fall-run Chinook salmon eggs in NO ACTION based on the 1999 – 2006 population average.

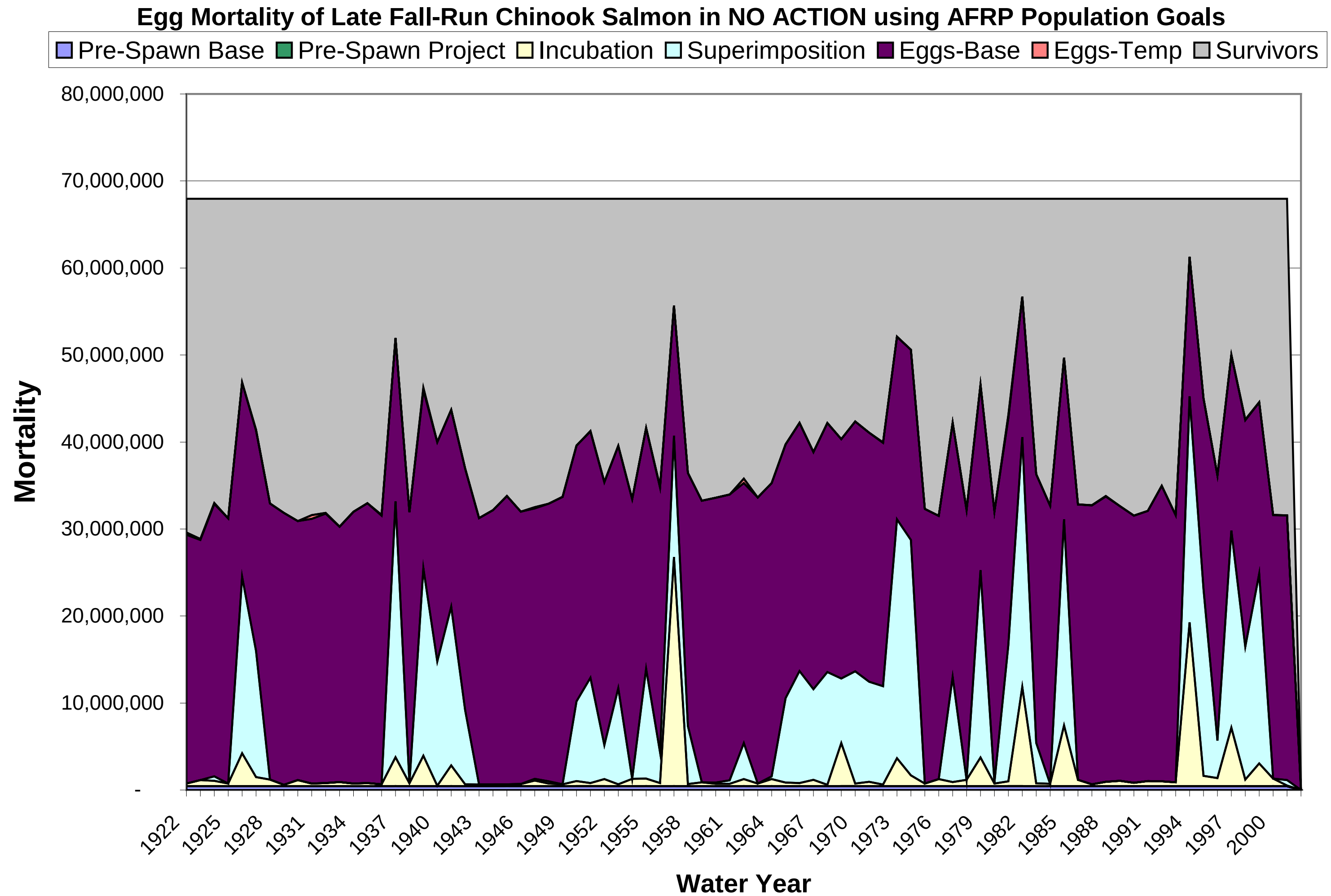

Figure 4B. Source of mortality of late fall-run Chinook salmon eggs in NO ACTION based on the AFRP population goals.

Consequently, in most years, operation of the dam precludes or substantially reduces opportunities for establishment of cottonwoods and willows. As a result of this (and other alterations to the flow regime of the Sacramento River), the structure and species composition of riparian vegetation has been changing within the primary study area and in portions of the extended study area (Fremier 2003; Roberts *et al.* 2002). The extent of early-successional riparian communities (*e.g.*, cottonwood forest) has been decreasing while the extent of mid-successional communities (*e.g.*, mixed riparian forest) has been increasing. This change, which would continue under the No Action Alternative, would have consequences for wildlife species because early- and mid-successional riparian vegetation provide for different habitat values. However, restoration projects proposed through CVPIA and Senate Bill 1086 are expected to restore riparian vegetation along parts of the Sacramento River and tributaries.

Wildlife

In the No Action Alternative, there would not be any changes to existing facilities or to the operation of reservoirs. As a result, there would be no temporary disturbance, loss of wildlife habitat, or threats to nesting birds due to construction or operation of new facilities. There would, however, continue to be an alteration of the structure and species composition of riparian vegetation resulting from continued operation of the existing Shasta Dam. Operation of the dam has led to the decrease in early successional riparian communities and an increase in the extent of mid-successional riparian communities. This change, which would continue under the No Action Alternatives, has consequences for wildlife species because early- and mid-successional riparian vegetation provides different habitat values. However, restoration projects mandated through CVPIA, AFRP, and Senate Bill 1086 are expected to improve conditions for wildlife along the Sacramento River and tributaries.

Special-status Species

In the No Action Alternative, there would not be any changes to existing facilities or to the operation of reservoirs. As a result, there would be no temporary or long-term disturbance or loss of special-status plant, wildlife and fish species, or altered structure or species composition from construction or operation of new facilities. There would, however, continue to be an alteration of the structure and species composition of riparian habitat resulting from continued operation of the existing Shasta Dam. Dam operations have led to the decrease in early successional riparian communities and an increase in the extent of mid-successional riparian communities in the Sacramento River, downstream. This change, which would continue under the No Action Alternative, has consequences for special-status wildlife and fish species because early- and mid-successional riparian vegetation provide different habitat values. However, restoration projects mandated through CVPIA, AFRP, and Senate Bill 1086 are expected to improve conditions for special-status species along the Sacramento River and tributaries.

In addition, in the No Action Alternative, there would not be any changes in reservoir operations, nor in the Sacramento River flow regimes or water temperatures, and therefore there would be no additional impacts to special-status fish (both anadromous and resident) beyond what currently occurs (*e.g.*, unsuitable water temperatures for some spawning fish, continued blockage of fish passage, continued blockage of coarse sediments necessary for spawning habitat).

Climate change is expected to affect special-status salmonids in the future by increasing temperatures, changes in precipitation patterns, and decreases in snow melt. Lindley *et al.* (2007) evaluated the effects of increasing temperatures on the availability of suitable over-summer habitat for spring-run Chinook salmon in the Central Valley. With a 2^{o}C warming, all historic over-summer habitat for spring-run Chinook salmon in the Tuolumne, Merced, and upper San Joaquin rivers, and Butte Creek would be lost as mean August air temperatures increase over 25^{o}C.

FUTURE CONDITIONS WITH PROJECT

<u>Primary Study Area: Shasta Lake and Tributaries and Keswick Reservoir</u>

Aquatic Habitat

The SLWRI dam raise alternatives would result in an increase in the size of Shasta Lake and the conversion of spawning and rearing habitat in the lower reaches of tributaries entering the lake from riverine to lacustrine. The effects of the dam raise on littoral habitat depend on whether vegetation is removed from the Inundation Zone. The increase in surface area of Shasta Lake would produce a greater volume of heated surface water in storage.

Shasta Lake and Tributaries and Adjacent Habitat

<u>Sedimentation and Turbidity</u>

Construction activities could result in an increase in sedimentation and turbidity of the waters surrounding the construction site following storm events. These conditions, if prolonged, can affect the growth survival, and reproductive success of aquatic organisms. Prolonged exposure to high levels of suspended sediment can create a loss of visual capability, leading to a reduction in feeding and growth rates; a thickening of the gill epithelium, potentially causing the loss of respiratory function; a clogging and abrasion of gill filaments; and increases in stress levels, reducing the tolerance of fish to disease and toxicants (Waters 1995).

Also, high suspended sediment levels would cause the movement and redistribution of fish populations and can affect physical habitat. Once the suspended sediment is deposited, it can reduce water depths in pools, decreasing the water's physical carrying capacity for juvenile and adult fish (Waters 1995). Increased sediment loading can also degrade food-producing habitat downstream of the project area. Sediment loading can interfere with photosynthesis of aquatic flora and result in the displacement of aquatic fauna. Many fish, including juvenile salmonids, are sight feeders. Turbid waters reduce the fish's efficiency in locating and feeding on prey. Some fish, particularly juveniles, can get disoriented and leave areas where their main food sources are located, which can result in reduced growth rates.

Avoidance is the most common result of increases in turbidity and sedimentation. Fish will not occupy areas that are not suitable for survival, unless they have no other option. Some fish, such as bluegill and bass species, will not spawn in excessively turbid water (Bell 1991). Therefore, habitat can become limiting in systems where high turbidity precludes a species from occupying habitat required for specific life stages.

Increased turbidity and sedimentation could also be expected from increasing the size of Shasta Lake. Inundation and wave action along the new shoreline would increase erosion and mass wasting of sediments into the reservoir. Even greater fluctuations in reservoir levels are expected from an enlarged Shasta Dam. Fluctuations in reservoir levels would further increase erosion near the shoreline resulting in more barren land.

Water Quality

Short-term degradation of water quality and fish habitat may occur from accidental spills or seepage of hazardous materials during construction. The potential exists for fuel and concrete to spill into the waterway during construction. Various contaminants, such as fuel oils, grease, and other petroleum products used in construction activities, could be introduced into the water system, either directly or through surface runoff. Contaminants may be toxic to fish or cause altered oxygen diffusion rates and acute and chronic toxicity to aquatic organisms, thereby reducing growth and survival.

The SLWRI alternatives would further inundate abandoned mines and contaminated tailing piles around Shasta Lake resulting in a potential increase in loading of acid mine drainage and toxic mercury into Shasta Lake. During a site visit to Shasta Lake, acid drainage with a pH of 2 was observed near the Bully Hill Mine within the Inundation Zone (P. Uncapher, NSR, pers. comm. 2007). Increased mercury loading into Shasta Lake could increase the levels of mercury in fish and invertebrates in the lake. The mercury would then bioaccumulate in sensitive raptor species that feed on fish in Shasta Lake. Increased loading of mercury and toxic metals into Shasta Lake may affect the ability of Keswick Reservoir to dilute the acid mine drainage from the Iron Mountain Mine Superfund site. This may result in increased loading of mercury and heavy metals into spawning habitat in the Sacramento River and further downstream into the Delta.

Littoral Habitat

Snags and large woody debris are important cover for fish in Shasta Lake. Further inundation of trees along the shoreline within the Inundation Zone would create more snags important for fish cover provided the woody debris is not removed. At this time, no information is available regarding whether inundated snags would be removed or not from Shasta Lake. Wave action combined with fluctuations in reservoir levels would further erode littoral habitat resulting in more barren land near the shoreline.

Loss of Riverine Habitat

The project would result in the conversion of riverine habitat to lacustrine habitat within the lower reaches of the hundreds of tributaries that enter Shasta Lake. The tributaries are important spawning and rearing habitat for trout and other fish species within the lake. The inundation of the lower McCloud River may affect its status as a Wild and Scenic River. Rapid fluctuations in reservoir levels would likely disturb fish spawning in riverine areas, particularly if the rate of filling of the reservoir increases during the spring. Sedimentation and deposition patterns in the tributaries would change with the conversion of the lower reaches from riverine to lacustrine. The inundation of the lower reach of tributaries would also affect seed dispersal of riparian vegetation.

The inundation of the lower reaches of tributaries would also have effects on the following fluvial and biological characteristics of the stream channels: changes in channel location, channel geometry, slope, form, turbidity, sedimentation, nutrients, erosion, mass wasting, channel aggradation or degradation, incision, cutbanks, loss of SRA cover, and increase in predator habitat for stream fish.

CP1 – 6.5-Foot Dam Raise

There is no data available at this time for the amount of riverine habitat that would be converted to lacustrine habitat in CP1.

CP2 – 12.5-Foot Dam Raise

There is no data available at this time for the amount of riverine habitat that would be converted to lacustrine habitat in CP2.

CP3, CP4, and CP5 – 18.5-Foot Dam Raise

CP3, CP4, and CP5 would result in an increase in gross pool area of about 2,570 acres. This amounts to an average increase in landward encroachment of the water surface around the reservoir at gross pool of about 50 feet. The distance would be greater along inflowing streams and creeks. Over 27 acres of the McCloud River riverine habitat would be inundated and converted to lacustrine habitat. CP3, CP4, and CP5 would have the greatest fluctuations in reservoir levels resulting in the greatest amount of shoreline erosion and disturbance of spawning habitat. There is no data available at this time for the total amount of riverine habitat that would be converted to lacustrine habitat in CP3, CP4, and CP5. There are over 300 tributaries that enter Shasta Lake that would be affected.

CP5 also provides for some form of environmental restoration around Shasta Lake. The details of such environmental restoration, however, are not available at this time.

Special-Status Aquatic Species

Aquatic special-status species such as hardhead, California roach, and rough sculpin would be affected by the conversion of riverine habitat to lacustrine in the lower reaches of the numerous tributaries entering Shasta Lake. This would also increase the amount of deep-water habitat available for predator species. Special-status aquatic species also may be affected by water quality impairment through temporary increases in sedimentation and turbidity associated with construction. Amphibian and reptile special-status species such as foothill yellow-legged frog and northwestern pond turtle may be adversely affected by the conversion of riverine habitat to lacustrine. The inundation of roads, culverts, and other structures may create other adverse effects by creating barriers to fish passage and restricting the movement of amphibians and other aquatic species.

Terrestrial/Wetland Vegetation and Wildlife

Inundation of Upland Habitat

The proposed project would result in the permanent loss of upland habitat within the Inundation Zone around Shasta Lake. Upland habitat types that would be affected include annual grassland, blue oak –gray pine woodland, blue oak woodland, closed-cone pine – cypress, mixed chaparral, montane hardwood – conifer, montane hardwood, montane riparian, ponderosa pine, and Sierran mixed conifer. The quantity and quality of upland habitat that would be lost is analyzed in greater detail in the draft HEP report which is attached in Appendix F of this document. A final

HEP report will be completed by the Service pending additional data to be submitted by NSR and information associated with habitat disturbance from dam construction activities and the relocation of campgrounds, roads, bridges, and other facilities to areas above the Inundation Zone. Additionally, more information is required on habitat disturbance associated with construction-related activities and the relocation of campgrounds, roads, bridges, marinas, and other facilities before the HEP report can be written. Finally, a mitigation strategy which identifies specific mitigation sites needs to be identified before the HEP report can be completed.

CP1 – 6.5 Foot Dam Raise

The raising of Shasta Dam by 6.5 feet in CP1 would raise the elevation of the reservoir at gross pool by 8.5 feet. There is no information available at this time to evaluate how much habitat would be permanently lost by inundation in CP1.

CP2 – 12.5-Foot Dam Raise

The raising of Shasta Dam by 12.5 feet in CP1 would raise the elevation of the reservoir at gross pool by 14.5 feet. There is no information available at this time to evaluate how much habitat would be permanently lost by inundation in CP1.

CP3, CP4, and CP5 – 18.5-Foot Dam Raise

The raising of Shasta Dam by 18.5 feet in CP3, CP4, and CP5 would raise the elevation of the reservoir at gross pool by 20.5 feet. Therefore, CP3, CP4, or CP5 would result in the permanent loss of the following habitats (WHRs) around Shasta Lake due to inundation (preliminary data from NSR 2004):

- Annual grassland 4.62 acres
- Blue oak –gray pine 50.51 acres
- Blue oak woodland 3.29 acres
- Closed-cone pine – cypress 189.64 acres
- Mixed chaparral 239.41 acres
- Montane hardwood – conifer 681.23 acres
- Montane hardwood 444.24 acres
- Montane riparian 57.90 acres
- Ponderosa pine 758.25 acres
- Sierran mixed conifer 17.05 acres

Shoreline Erosion and Mass Wasting

The inundation of upland habitat would result in accelerated shoreline erosion and mass wasting. This would increase the amount of barren lands near the shoreline. CP3, CP4, and CP5 are expected to have the highest rate of fluctuation in reservoir levels resulting in the greatest amount of erosion of upland habitat surrounding the reservoir.

Construction-Related Disturbance

Construction-related disturbances during construction activities at Shasta Dam could temporarily disturb and/or permanently eliminate common plant communities, including annual grassland and chaparral, and sensitive oak communities including blue oak savanna, foothill pine-oak woodland, and valley oak woodland. The proposed aggregate mining that would likely occur in the primary study area (to supply the project with materials needed for the dam raise) could also result in the temporary disturbance or permanent loss of common plant communities. Because the exact location and size of the staging areas, travel routes, and mining sites have not been determined, the possibility of temporary or permanent disturbance of common plant communities cannot be eliminated. Additionally, relocation of campgrounds, roads, bridges, marinas, and other facilities beyond the Inundation Zone would result in the permanent and/or temporary loss of common and sensitive plant communities near Shasta Lake. At this time, there is no information available on where facilities would be relocated and the size of the disturbance. Therefore, we cannot estimate at this time the amount of each habitat type that would be disturbed by the relocation of facilities.

Construction-related disturbances could temporarily disturb wildlife, nesting raptors, and migratory birds associated with habitat in the vicinity of the construction site and staging areas. These impacts could interfere with the movement of native or migratory wildlife or the use of nursery sites. Construction-related activities could result in increased road kills and nest abandonment.

<u>CP1 – 6.5 Foot Dam Raise</u>

Construction of CP1 would involve raising the main concrete dam and several dikes by 6.5 feet, replacement of 7 bridges, and modification of 75 small road segments. An unknown number of campgrounds, marinas, and other facilities would have to be relocated. There is no information available at this time to evaluate how much habitat would be temporarily or permanently disturbed by project-related construction activities in CP1.

<u>CP2 – 12.5-Foot Dam Raise</u>

Construction of CP2 would involve raising the main concrete dam and several dikes by 12.5 feet, replacement of 7 bridges, and modification of 95 small road segments. An unknown number of campgrounds, marinas, and other facilities would have to be relocated. There is no information available at this time to evaluate how much habitat would be temporarily or permanently disturbed by project-related construction activities in CP2.

CP3, CP4, and CP5 – 18.5-Foot Dam Raise

Construction of CP3, CP4, or CP5 would involve raising the main concrete dam by 18.5 feet, raising 3 minor dikes, replacement of 7 bridges, and modification of over 100 small road segments. An unknown number of campgrounds, marinas, and other facilities would have to be relocated. There is no information available at this time to evaluate how much habitat would be temporarily or permanently disturbed by project-related construction activities in CP3, CP4, and CP5.

CP5 also provides for some form of environmental restoration around Shasta Lake. The details of such environmental restoration, however, are not available at this time.

Rare and Special-Status Floral Species

Shasta Snow-Wreath

Nine populations (43 percent of all known populations), including four large populations, of Shasta snow-wreath could be partly or permanently lost within the Inundation Zone (NSR 2004, Lindstrand and Nelson 2005a,b). It is not known at this time what percent of the total number of individual plants of Shasta snow-wreath could be lost. Additional populations of Shasta snow-wreath may be disturbed by construction activities, the relocation of facilities, and further spreading of invasive species. Another eight populations of Shasta snow-wreath are currently threatened by non-project related activities (*e.g.*, mining, development, fire, invasive species, and other human-related disturbances) due to their locations along roads, trails, and logging areas (Lindstrand and Nelson 2005a,b, Lindstrand 2007). Only four populations of Shasta snow-wreath (19 percent of all known populations) due to their remote locations are not currently threatened by the SLWRI or non-project related activities (Lindstrand 2007). The CALFED Programmatic EIS/EIR includes Shasta snow-wreath among "evaluated species for which direct mortality as a result of implementing CALFED actions is prohibited as a condition of the Multi-Species Conservation Strategy" (Table 4-5 in MSCS section of CALFED 2000b).

Cantelow's Lewisia

One population was observed within the Inundation Zone on a rock outcrop on the right bank of the Upper Sacramento River riverine reach near the Shasta Lake/Upper Sacramento River transition zone (NSR 2004). This population and potentially others would be lost due to inundation or disturbance associated with the relocation of campgrounds, roads, bridges, and other facilities.

Shasta Huckleberry

Nine Shasta huckleberry shrubs are known to occur within the Inundation Zone along the Little Big Backbone Creek drainage (L. Lindstrand, NSR, pers. comm. 2007; J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007). These shrubs and potentially others would be lost due to inundation or disturbance associated with the relocation of campgrounds, roads, bridges, and other facilities.

Northern Clarkia

One population of northern clarkia would likely be inundated near the town of Sugarloaf along the Sacramento River arm (CDFG 2007a). Two additional populations near Bailey Cove along the McCloud River arm and near Allie Cove on the mainbody of Shasta Lake are outside of the Inundation Zone but could be disturbed by the relocation of campgrounds, roads, bridges, and other facilities (CDFG 2007a; J. Nelson, USFS/STNF; pers. comm., 2008). Potential habitat and other unknown populations may be lost due to inundation or disturbance as well.

Shasta Clarkia

The closest known occurrence of Shasta clarkia to Shasta Lake is less than 2.5 km southeast of the Pit River arm (CDFG 2007a). Although this occurrence would not be inundated, it and other unknown occurrences and potential habitat could be disturbed by the relocation of campgrounds, roads, bridges, and other facilities. The CALFED Programmatic EIS/EIR includes Shasta clarkia among “evaluated species for which direct mortality as a result of implementing CALFED actions is prohibited as a condition of the Multi-Species Conservation Strategy” (Table 4-5 in MSCS section of CALFED 2000b).

Silky Cryptantha

The closest known occurrence of silky cryptantha to Shasta Lake is about 7 km south of Allie Cove (CDFG 2007a). However, potential habitat and other unknown populations of the species may be lost due to inundation or disturbance associated with the relocation of campgrounds, roads, bridges, and other facilities. The CALFED Programmatic EIR/EIS and ROD (CALFED 2000a,b) state that CALFED actions, such as the SLWRI, should not threaten the population viability of silky cryptantha. All CALFED actions must maintain the status of silky cryptantha and any adverse effects on the species must be fully offset through implementation of actions beneficial to the species.

Special-Status Terrestrial Mollusks

Shasta Chaparral Snail

There are 15 known occurrences of Shasta chaparral snail within the Inundation Zone along the Sacramento River, Mc Cloud River, Squaw Creek, and Pit River arms (Lindstrand 2007). These occurrences and potentially other unknown occurrences and habitat would be lost due to inundation or disturbance associated with the relocation of campgrounds, roads, bridges, and other facilities.

Shasta Hesperian Snail

There are 31 known occurrences of Shasta hesperian snail in riparian habitat within the Inundation Zone along the Sacramento River, Mc Cloud River, Squaw Creek, and Pit River arms (Lindstrand 2007). All of these occurrences as well as other unknown occurrences and potential habitat would be lost due to inundation or disturbance associated with the relocation of campgrounds, roads, bridges, and other facilities. There are over 2,000 tributaries that enter

Shasta Lake many of which contain potential habitat for Shasta hesperian snail that would be lost.

Shasta Sideband

Shasta sideband snails are restricted to limestone outcrops in the vicinity of Shasta Lake along the McCloud River arm (Lindstrand 2007). There are four known occurrences of Shasta sidebands within the Inundation Zone along the McCloud River arm (Lindstrand 2007, NSR 2004). It is not known at this time how many acres of limestone outcrop habitat would be lost within the Inundation Zone. These occurrences and potentially other unknown occurrences and habitat would be lost due to inundation or disturbance associated with the relocation of campgrounds, roads, bridges, and other facilities. It is not known what percent of the total population and potential habitat would be lost. The CALFED Programmatic EIS/EIR states that CALFED actions, such as SLWRI, should not threaten the population viability of the Shasta sideband (CALFED 2000a,b).

Wintu Sideband

Wintu sideband snails are restricted to limestone outcrops in the vicinity of Shasta Lake along the Pit River arm (Lindstrand 2007). There are two known occurrences of Wintu sidebands within the Inundation Zone along the Pit River arm (Lindstrand 2007, NSR 2004). It is not known at this time how many acres of limestone outcrop habitat would be lost within the Inundation Zone. These occurrences and potentially other unknown occurrences and habitat would be lost due to inundation or disturbance associated with the relocation of campgrounds, roads, bridges, and other facilities. It is not known what percent of the total population and potential habitat would be lost.

Special-Status Amphibians and Reptiles

Foothill Yellow-Legged Frog

Foothill yellow legged-frog would be adversely affected by the inundation of riverine, riparian, and surrounding upland habitat and conversion into lacustrine habitat. The inundation would also allow predatory species access to foothill yellow-legged frog habitat, further fragment existing habitat, and create barriers to movement. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of foothill-legged frog habitat that would be permanently or temporarily disturbed.

Shasta Salamander

Shasta salamander would be adversely affected by the inundation of limestone, mixed conifer, woodland, and chaparral habitats. The inundation would also allow predatory species access to Shasta salamander habitat, further fragment existing habitat, and create barriers to movement. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of Shasta salamander habitat that would be permanently or temporarily disturbed.

Northwestern Pond Turtle

Northwestern pond turtle would be adversely affected by the inundation of riverine, riparian, wetland and surrounding upland nesting habitat and conversion into lacustrine habitat. The inundation would also allow predatory species access to northwestern pond turtle habitat, further fragment existing habitat, and create barriers to movement. Additional habitat would be temporarily or permanently disturbed by dam construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of northwestern pond turtle habitat that would be permanently or temporarily disturbed.

Special-Status Mammals

Pacific Fisher

Pacific fisher would be adversely affected by the inundation of mixed conifer and conifer/woodland habitats. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of Pacific fisher habitat that would be permanently or temporarily disturbed.

Ringtail

Ringtail would be adversely affected by the inundation of mixed conifer and conifer/woodland habitats. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of ringtail habitat that would be permanently or temporarily disturbed.

Great Western Mastiff-Bat

Great western mastiff-bat and other bat species would be adversely affected by the inundation of roosting habitat within caves and abandoned mines and foraging habitat within mixed conifer and conifer/woodland habitats. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of great western mastiff-bat (and other bats) habitat that would be permanently or temporarily disturbed.

Special-Status and Migratory Birds

<u>Northern Spotted Owl</u>

Northern spotted owl would be adversely affected by the inundation of coniferous forest habitat. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of northern spotted owl habitat that would be permanently or temporarily disturbed.

<u>Western Purple Martin</u>

Western purple martin would be adversely affected by the complete inundation of partly inundated snags that provide suitable nesting habitat particularly in the Pit River arm. Additional snag nesting habitat could be lost by greater fluctuations in water levels accelerating the rate of decay of partly inundated snags. Other suitable snags may be cleared within the Inundation Zone for access and human safety. Although the inundation of trees within the Inundation Zone would likely create additional snags, there would be a time lag of decades before the newly inundated snags would provide suitable nesting habitat for the western purple martin. This could result in the western purple martin abandoning the important nesting sites in the Pit River arm (G. Boler, NSR, pers. comm., 2007). There is no estimate available at this time for the amount of western purple martin nesting habitat that would be permanently or temporarily disturbed.

<u>Yellow-Breasted Chat</u>

Yellow-breasted chat would be adversely affected by the inundation of riparian habitat and adjacent uplands. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of yellow-breasted chat habitat that would be permanently or temporarily disturbed.

<u>Little Willow Flycatcher</u>

Little willow flycatcher would be adversely affected by the inundation of riparian habitat and adjacent uplands. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of little willow flycatcher habitat that would be permanently or temporarily disturbed.

<u>Long-Eared Owl</u>

Long-eared owl would be adversely affected by the inundation of coniferous forest habitat. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of long-eared owl habitat that would be permanently or temporarily disturbed.

Osprey

Osprey would be adversely affected by the inundation of riverine habitat and adjacent uplands. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of osprey habitat that would be permanently or temporarily disturbed.

American Peregrine Falcon

American peregrine falcon would be adversely affected by the inundation mixed conifer and conifer/woodland habitats. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of American peregrine falcon habitat that would be permanently or temporarily disturbed.

Great Blue Heron

Great blue heron would be adversely affected by the inundation riparian and wetland habitats and the conversion into lacustrine habitat. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of great blue heron habitat that would be permanently or temporarily disturbed. A great blue heron rookery occurs at Turntable Bay and may be adversely affected by the inundation.

California Yellow Warbler

California yellow warbler would be adversely affected by the inundation of riparian habitat and adjacent uplands. Additional habitat would be temporarily or permanently disturbed by dam, levee, and dike construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of California yellow warbler habitat that would be permanently or temporarily disturbed.

Bald Eagle

The bald eagle is currently protected by the Bald and Golden Eagle Protection Act. Bald eagles would be affected by the loss of nesting habitat in riverine areas within the Inundation Zone. There are at least four known bald eagle nest sites that occur within the Inundation Zone. Additional habitat would be temporarily or permanently disturbed by dam construction activities as well as the relocation of campgrounds, marinas, roads, bridges, and other facilities beyond the Inundation Zone. There is no estimate available at this time for the amount of bald eagle habitat that would be permanently or temporarily disturbed.

Primary Study Area: Sacramento River between Keswick Dam and RBDD

Aquatic Habitat

One of two primary objectives of the SLWRI is increasing the survival of anadromous fish. However, in all of the proposed alternatives, benefits to anadromous fish survival are limited to improvements to the TCD and increasing the size of the cold water pool available to maintain cooler temperatures in the Sacramento River between Keswick Dam and RBDD. However, salmonid population modeling in Salmod shows that in the majority of years the SLWRI results in no benefit, or even a slight decrease, in the survival of anadromous fish. Only in a few dry and critically dry water years does the SLWRI result in significant increases in the production of anadromous fish due to an enlarged cold water pool.

Another effect of the SLWRI is changes in the timing, frequency, and duration of flood flows in the Sacramento River between Keswick Dam and the RBDD. Flood flows are important for mobilizing sediment and maintaining a diversity of riparian habitat to improve spawning and rearing habitat for anadromous fish. In the SLWRI, hydrological data is provided in monthly time steps through CALSIM II. However, flooding and temperature conditions operate on finer time scales from hours to weeks. Therefore, CALSIM II is unable to adequately simulate the effects of the SLWRI alternatives on flooding and temperature conditions in the Sacramento River. Below is a discussion of the effects of the SLWRI alternatives on the hydrology and aquatic habitat of the Sacramento River between Keswick Dam and RBDD.

Another potential effect of raising Shasta Dam is an increase in the loading of toxic mercury, cadmium, copper, and zinc from Keswick Reservoir to important spawning habitat in the Sacramento River downstream from Keswick Dam. The raising of Shasta Dam may result in the inundation of abandoned mines and mine tailings resulting in an increase in the loading of acid mine drainage into Shasta Lake that would be transported into Keswick Reservoir. This increased loading would reduce the ability of Keswick Reservoir to dilute acid mine drainage from the Iron Mountain Mine Superfund site resulting in increased loading of toxic metals into prime spawning habitat for anadromous fish in the Sacramento River.

The SLWRI alternatives could also potentially result in the release of toxic heavy metals from the sediments in Keswick Reservoir into the water column. Managing the reservoir and the power plant for peak hydroelectric power generation requires lowering Keswick Reservoir, which could expose the sediments to scouring action, potentially mobilizing metals in the water column and creating conditions toxic to aquatic organisms (Fujimara *et al.* 1995, Finlayson *et al.* 2000). Uncontrolled discharge of acid-mine drainage into the Sacramento River has resulted in high levels of cadmium, copper, and zinc, which has caused fish kills (CH2M-Hill 1992).

Hydrology

Figure 5 below compares the frequency distribution of monthly flows out of Keswick Dam for the No Action and SLWRI alternatives. The graph shows that there are no significant changes in the frequency and intensity of flood flows or drought flows among the No Action and the SLWRI alternatives. However, the CALSIM output data is for monthly flows and would likely mask any changes in the intensity and duration of flood flows that occur on a daily or weekly timestep. Flood flows are geomorphically and ecologically significant for mobilizing bed substrate and the creation of a mix of riparian successional states. Additionally, a reduction in flood flows in the main stem Sacramento River would likely result in further downcutting of the tributaries and loss of riparian habitat.

Also important is the timing of flows which is discussed below for each of the alternatives. Anadromous fish and other aquatic species evolved to adapt to predictable changes in the seasonality of flows in the Sacramento River. Historically, flows in the Sacramento River increased through the winter and spring wet season decreasing through the summer dry season to a minimum in early fall. However, since the construction and operation of Shasta Dam, the seasonal distribution of flows was disrupted resulting in decreases in flood flows during the winter and spring and increases in summer flows to provide water for irrigation and M&I.

A recent study of breeding riparian songbirds along the Sacramento River (Small 2007) found that the median flood date (50,000 cfs flows) was the most significant variable for predicting the nesting success of black-headed grosbeaks. Black-headed grosbeaks nest in mid-canopy riparian vegetation from May – July along the Sacramento River. Flood flows close to the springtime breeding season were found to increase the nest survival rate of black-headed grosbeaks by reducing the activity of mammalian predators (*e.g.*, rats and raccoons) (Small 2007). Thus a decrease in spring flood flows with an enlarged Shasta Dam could result in a decrease in the nest survival rate of black-headed grosbeaks due to increased springtime activity of mammalian predators.

The timing of flood flows was also found to affect the relative distribution of native riparian vegetation and exotic plant species. A study of the seed composition of winter and spring sediment traps along the Sacramento River between Hamilton City and Colusa showed a greater proportion of native riparian vegetation (*e.g.*, willows) seeds associated with spring flood events while winter flood events resulted in a greater proportion of non-native plant species (Little 2007). Thus a further decrease in spring flood flows with the SLWRI could result in a decrease in native riparian vegetation and increase in exotic plant species. The enlargement of Shasta Dam with the SLWRI is likely to result in a further departure from the natural seasonal cycle of flows in the Sacramento River.

Figure 6 shows the frequency distribution of the change in monthly flows out of Keswick Dam in the SLWRI alternatives relative to No Action. The graph illustrates that, relative to No Action, the SLWRI alternatives would result in a decrease in monthly flows out of Keswick Dam 25 percent of the time and an increase in monthly flows 25 percent of the time. Therefore, although the SLWRI alternatives may not change the frequency distribution of flows out of Keswick Dam (analyzed on a monthly time step) (Figure 5), they do change the timing of flows out of Keswick Dam relative to No Action (Figure 6).

The next series of graphs, Figures 7A – 7F, compare the average monthly flows out of Keswick by water year type (*i.e.*, wet, above normal, average, below normal, dry, and critical) among the No Action and SLWRI alternatives. Below is a discussion of what effect each of the SLWRI alternatives has on the monthly timing of flows for each water year type.

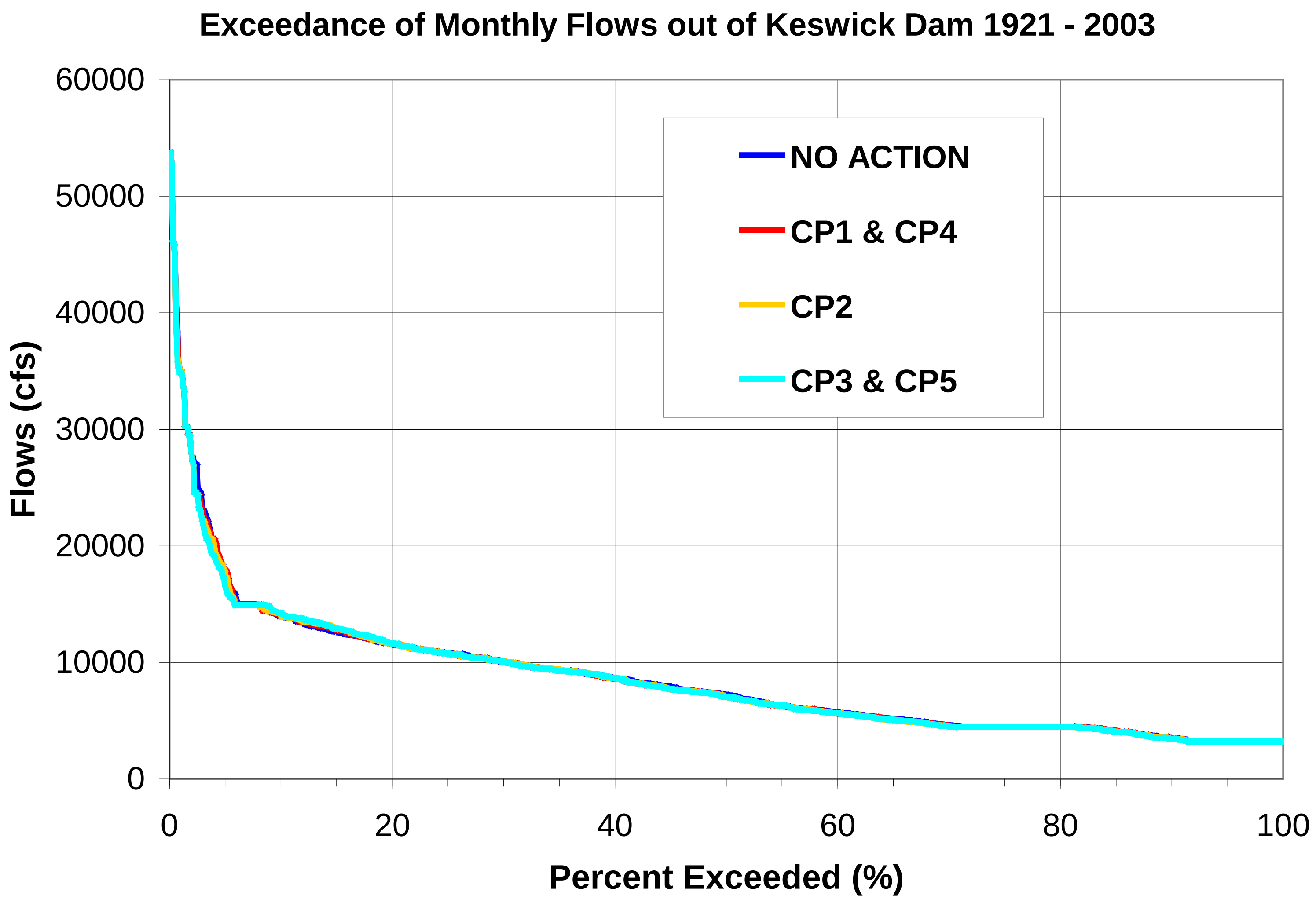

Figure 5. Frequency distribution of monthly flows out of Keswick Dam for the Oct. 1921 – Sept. 2003 CALSIM period of record.

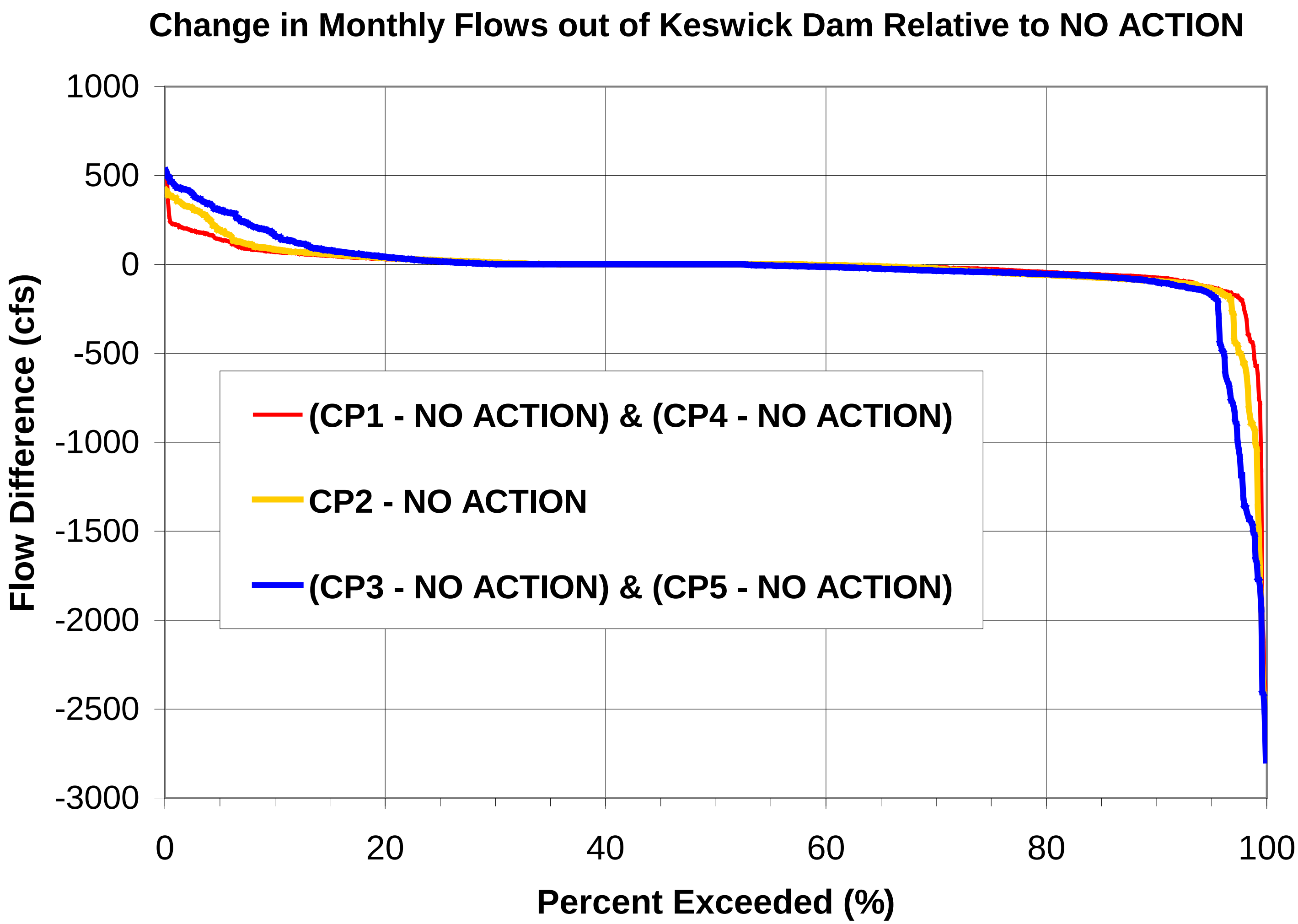

Figure 6. Frequency distribution of change in monthly flows out of Keswick Dam relative to NO ACTION.

CP1 – 6.5 Foot Dam Raise

Of the SLWRI alternatives, CP1 would have the least amount of cold water available to maintain cooler temperatures for anadromous fish in the Sacramento River between Keswick Dam and RBDD during dry and critical years. CP1, however, would have the least impact on altering the timing, frequency, and duration of ecologically important flood flows.

During average water years (Figure 7A), average monthly flows out of Keswick Dam decreased by 2 percent in December (147 cfs) and January (186 cfs) compared to No Action. During wet water years (Figure 7B), average monthly flows out of Keswick Dam decreased by 3 percent (427 cfs) in December and increased by 3 percent (375 cfs) in July compared to No Action. During above normal water year (Figure 7C), average monthly flows out of Keswick Dam decreased by 4 – 6 percent (290 – 550 cfs) in January – March and May compared to No Action. During below normal water years (Figure 7D), average monthly flows out of Keswick Dam decreased by 2 percent (126 – 133 cfs) in December and February compared to No Action. During dry water years (Figure 7E), average monthly flows out of Keswick Dam increased by 3 – 4 percent (334 – 364 cfs) in June - August compared to No Action. The greatest increase in flows occurred in February during critical water years (Figure 7F) when the average monthly flow out of Keswick increased by 30 percent (1,080 cfs) to 4,691 cfs compared to 3,611 cfs in No Action.

CP2 – 12.5-Foot Dam Raise

CP2 would provide more available cold water available than CP1 to maintain cooler temperatures for anadromous fish in the Sacramento River between Keswick Dam and RBDD during dry and critical years. CP2, however, would have a greater impact on altering the timing, frequency, and duration of ecologically important flood flows.

During average water years (Figure 7A), average monthly flows out of Keswick Dam decreased by 4 percent in December (314 cfs) and 2 percent in January (201 cfs) compared to No Action. During wet water years (Figure 7B), average monthly flows out of Keswick Dam decreased by 7 percent (824 cfs) in December and by 2 percent (433 cfs) in February but increased by 3 percent (397 cfs) in July compared to No Action. During above normal water years (Figure 7C), average monthly flows out of Keswick Dam decreased by 4 – 9 percent (393 – 779 cfs) in January – March and May compared to No Action. During below normal water years (Figure 7D), average monthly flows out of Keswick Dam decreased by 5 percent (280 and 326 cfs) in December and February compared to No Action. During dry water years (Figure 7E), average monthly flows out of Keswick Dam increased by 5 – 7 percent (606 – 669 cfs) in June - August compared to No Action. The greatest increase in flows occurred in February during critical water years (Figure 7F) when the average monthly flow out of Keswick increased by 20 percent (706 cfs) to 4,317 cfs compared to 3,611 cfs in No Action.

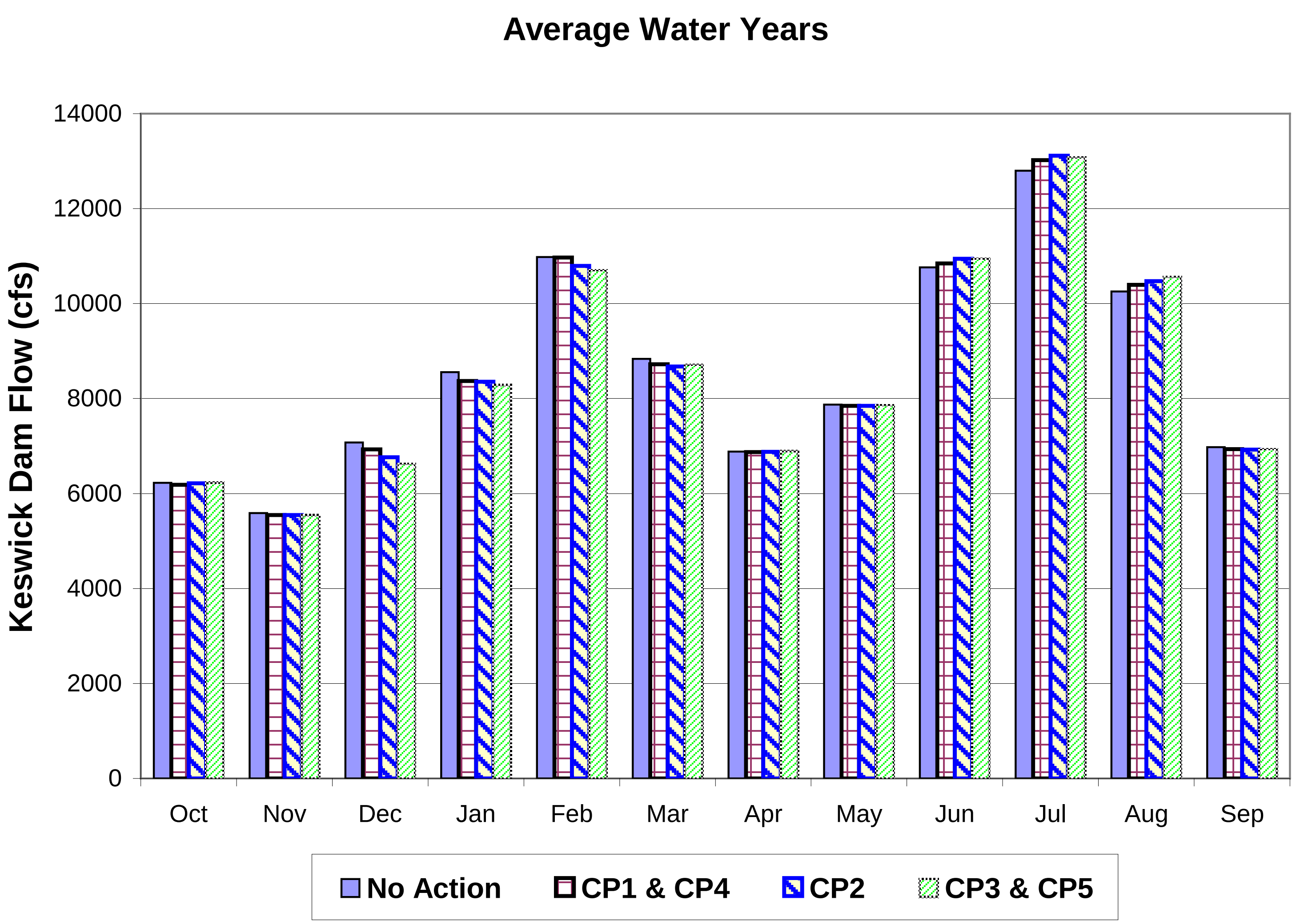

Figure 7A. Average monthly flows out of Keswick Dam during average water years for the 1921 – 2003 period of record.

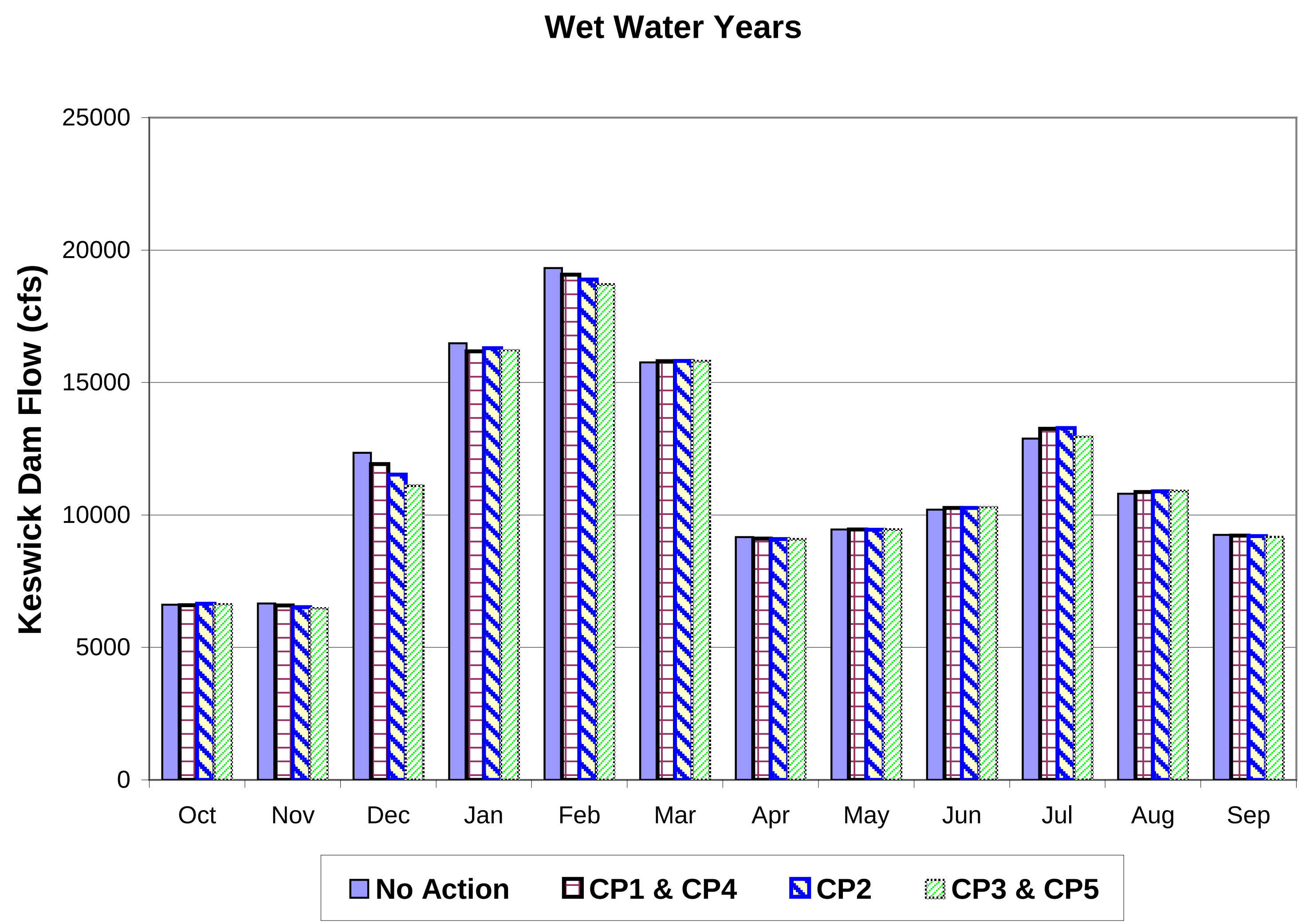

Figure 7B. Average monthly flows out of Keswick Dam during wet water years for the 1921 – 2003 period of record.

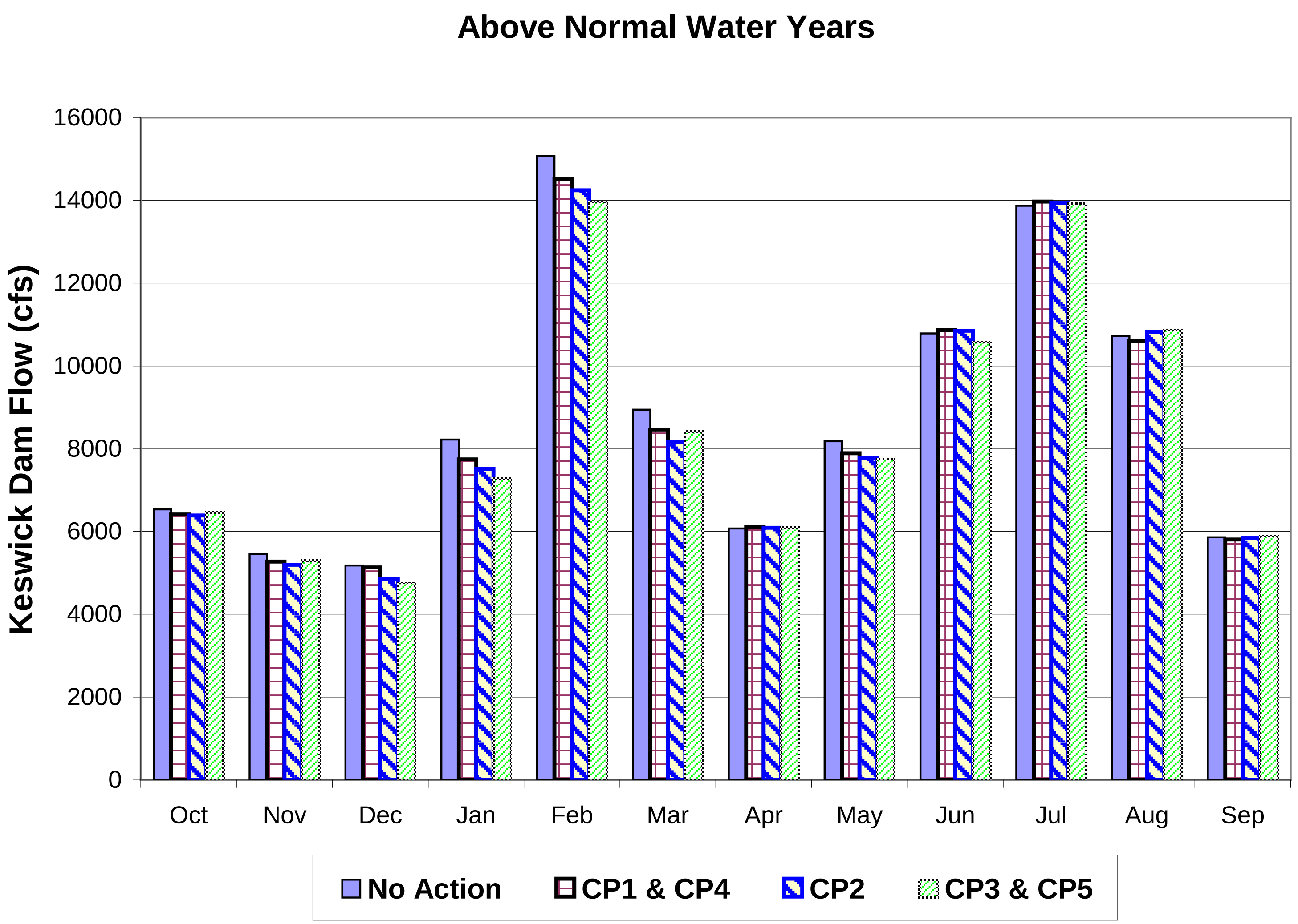

Figure 7C. Average monthly flows out of Keswick Dam during above normal water years for the 1921 – 2003 period of record.

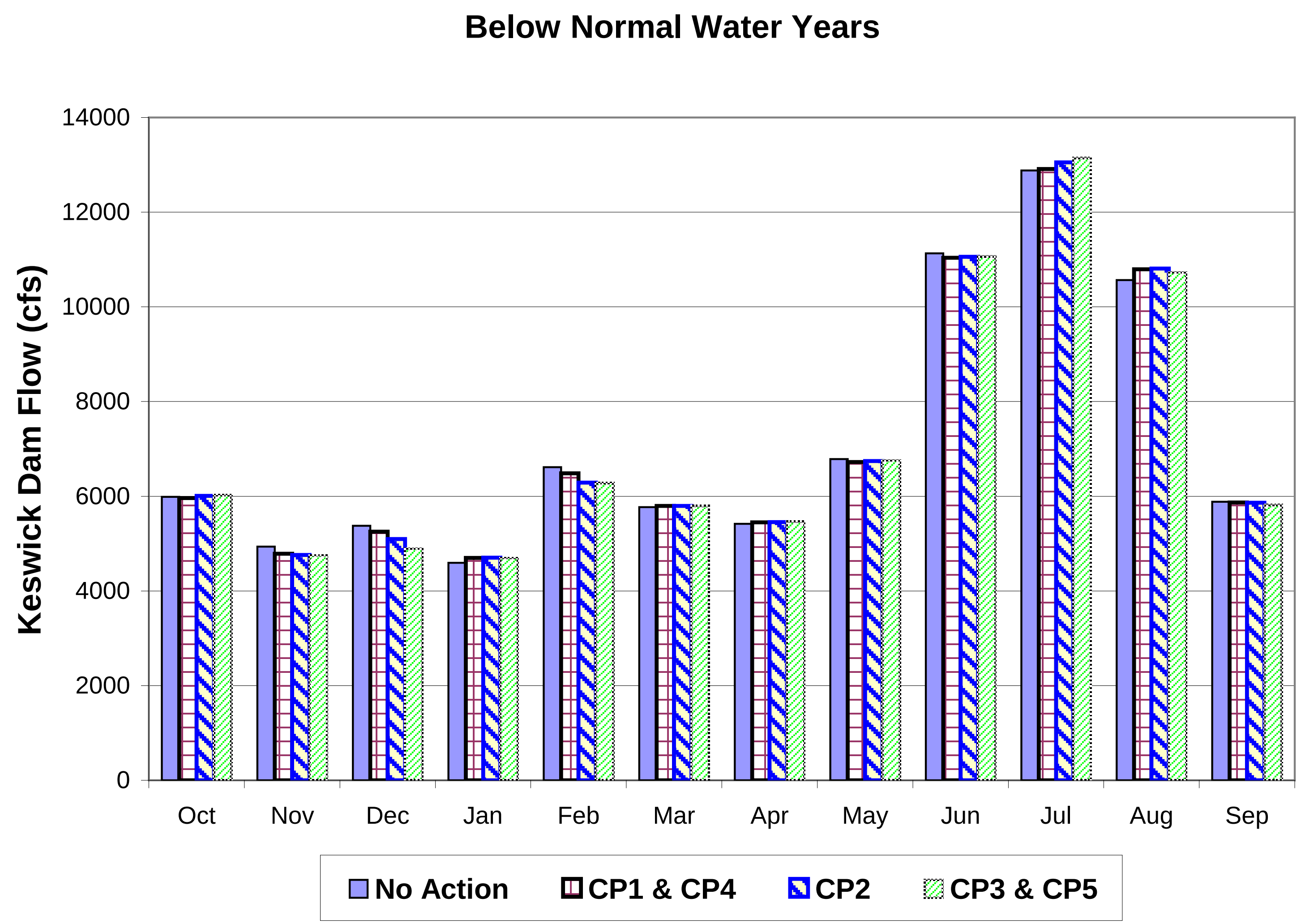

Figure 7D. Average monthly flows out of Keswick Dam during below normal water years for the 1921 – 2003 period of record.

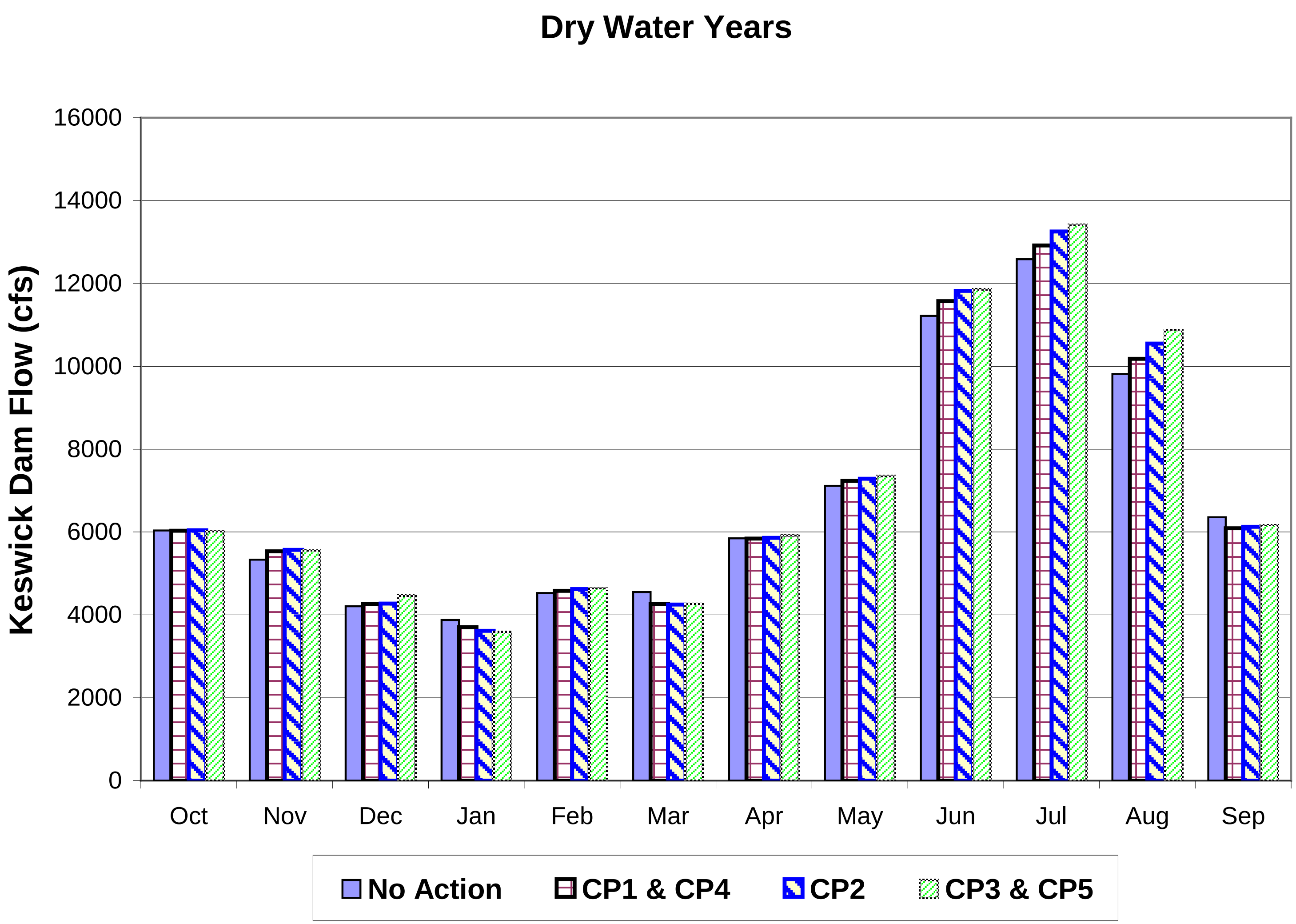

Figure 7E. Average monthly flows out of Keswick Dam during dry water years for the 1921 – 2003 period of record.

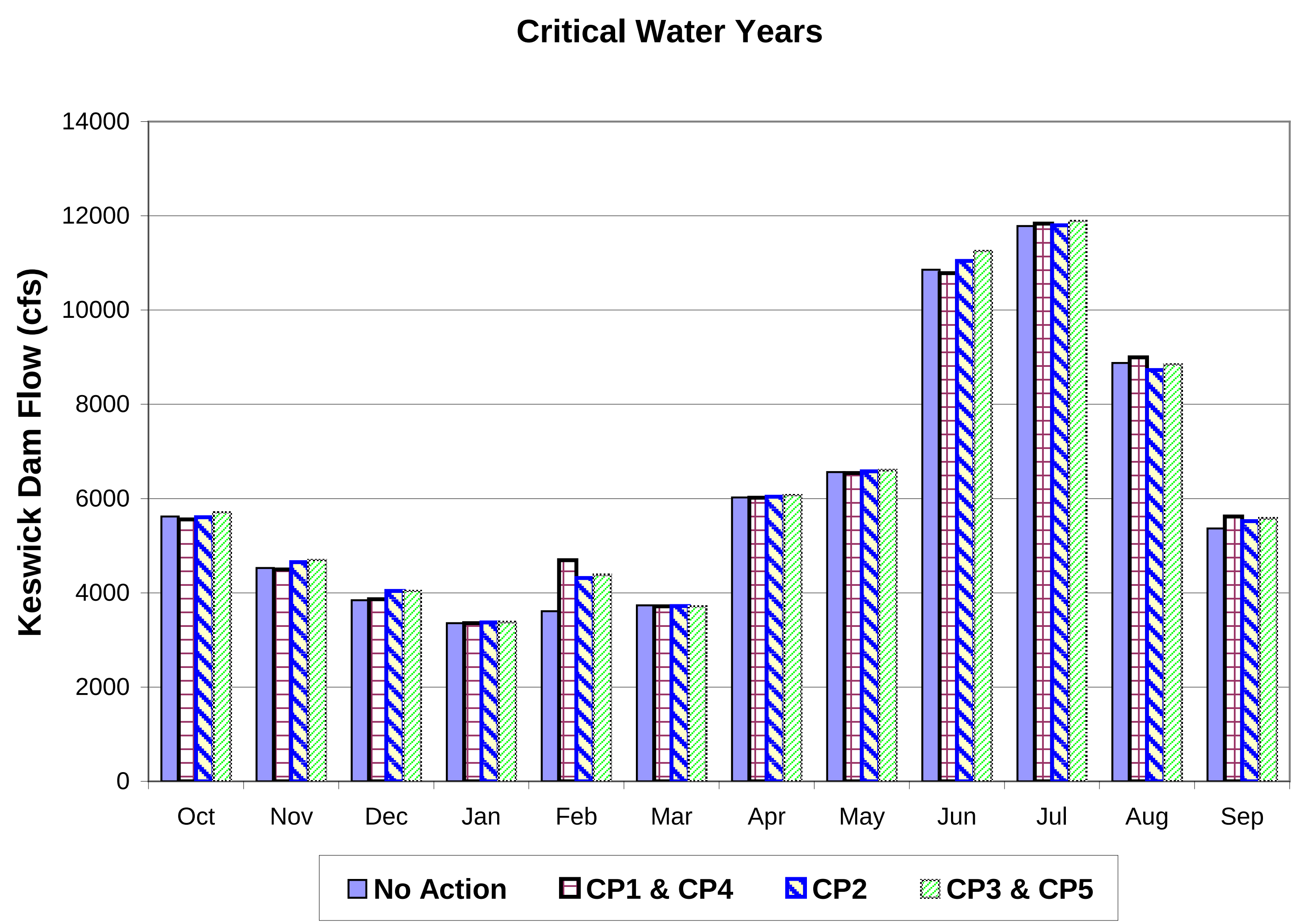

Figure 7F. Average monthly flows out of Keswick Dam during dry water years for the 1921 – 2003 period of record.

CP3 – 18.5-Foot Dam Raise

CP3 would provide more cold water storage than CP1 and CP2 to maintain cooler temperatures for anadromous fish in the Sacramento River between Keswick Dam and RBDD during dry and critical years. CP3 (and CP5), however, would have the greatest impact on altering the timing, frequency, and duration of ecologically important flood flows. Figure 2 shows that during five percent of the period of record, CP3 (and CP5) would result a decrease in monthly flows out of Keswick Dam by more than 500 cfs relative to No Action. An analysis of daily flow data (CALSIM II monthly flow data disaggregated into daily flows for use in Salmod; Yaworsky *in litt.* 2007) reveals that flood flows were significantly decreased by 1,000 – 25,000 cfs compared to No Action during eleven events over the period of record. The duration of flood events was also decreased in numerous flood events throughout the period of record.

During average water years (Figure 7A), average monthly flows out of Keswick Dam in CP3 (and CP5) decreased by 6 percent in December (451 cfs) and 3 percent in January - February (267 - 277 cfs) compared to No Action. During wet water years (Figure 7B), average monthly flows out of Keswick Dam decreased by 10 percent (1,241 cfs) in December and by 3 percent (617 cfs) in February compared to No Action. During above normal water years (Figure 7C), average monthly flows out of Keswick Dam would decrease by 5 –11 percent (438 – 1,113 cfs) in January – March and May compared to No Action. During below normal water years (Figure 7D), average monthly flows out of Keswick Dam would decrease by 9 and 5 percent (481 and 337 cfs) in December and February, respectively, compared to No Action but would increase by 2 percent (261 cfs) in July. During dry water years (Figure 7E), average monthly flows out of Keswick Dam would increase by 6 – 11 percent (642 – 1,057 cfs) in June - August compared to No Action. During critical water years (Figure 7F), average monthly flows in February would increase by 21 percent (773 cfs) from 3,611 cfs in No Action to 4,384 cfs in CP3.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus

Of the SLWRI alternatives, CP4 would provide the greatest amount of cold water available to maintain cooler temperatures for anadromous fish in the Sacramento River between Keswick Dam and RBDD during dry and critical years. CP4, like CP1, would also have the least impact on altering the timing, frequency, and duration of ecologically important flood flows.

In CALSIM hydrological modeling, the increased yield at Shasta Dam in CP4 is 256,000 af (the same as in CP1) because 378,000 af is assumed to remain in the reservoir for cold water storage. Therefore, the hydrological modeling results in CALSIM II for CP4 are the same as in CP1.

During average water years (Figure 7A), average monthly flows out of Keswick Dam in CP4 decreased by 2 percent in December (147 cfs) and January (186 cfs) compared to No Action. During wet water years (Figure 7B), average monthly flows out of Keswick Dam decreased by 3 percent (427 cfs) in December and increased by 3 percent (375 cfs) in July compared to No Action. During above normal water years (Figure 7C), average monthly flows out of Keswick Dam decreased by 4 – 6 percent (290 – 550 cfs) in January – March and May compared to No Action. During below normal water years (Figure 7D), average monthly flows out of Keswick Dam decreased by 2 percent (126 – 133 cfs) in December and February compared to No Action. During dry water years (Figure 7E), average monthly flows out of Keswick Dam increased by 3

– 4 percent (334 – 364 cfs) in June - August compared to No Action. The greatest increase in flows in CP4 occurred in February during critical water years (Figure 7F) when the average monthly flow out of Keswick increased by 30 percent (1,080 cfs) to 4,691 cfs compared to 3,611 cfs in No Action.

CP5 – 18.5-Foot Dam Raise, Combination Plan

The effects of CP5 on the flows in the Sacramento River between Keswick Dam and RBDD are identical to CP3 described above.

Anadromous Fish

One of two primary goals of the SLWRI is to increase survival of anadromous fish in the Sacramento River between Keswick Dam and RBDD. Salmod modeling was used to estimate annual immature smolt production for the four runs of Chinook salmon within the Sacramento River between Keswick Dam and RBDD for the No Action and SLWRI alternatives for water years 1922 – 2002. The first series of simulations (Figures 8A-D) used the 1999 - 2006 population average (CDFG 2007b) as the number of spawners returning. The 1999 – 2006 population average was used to simulate what effect the SLWRI alternatives would have on the current low numbers of Chinook salmon. The second series of simulations (Figures 9A-D) used the AFRP goals as the number of spawners returning. The AFRP adult escapement goals are based upon the stated objective in the 1992 CVPIA which sets the goals as the doubling of the 1967 – 1991 average escapement. The AFRP goals were simulated to determine what effect the SLWRI alternatives would have on Chinook salmon in the future when the number of Chinook salmon have significantly increased. It is expected that superimposition and competition for spawning and rearing habitat would become more of a limiting factor in the future if AFRP recovery programs double the number of Chinook salmon.

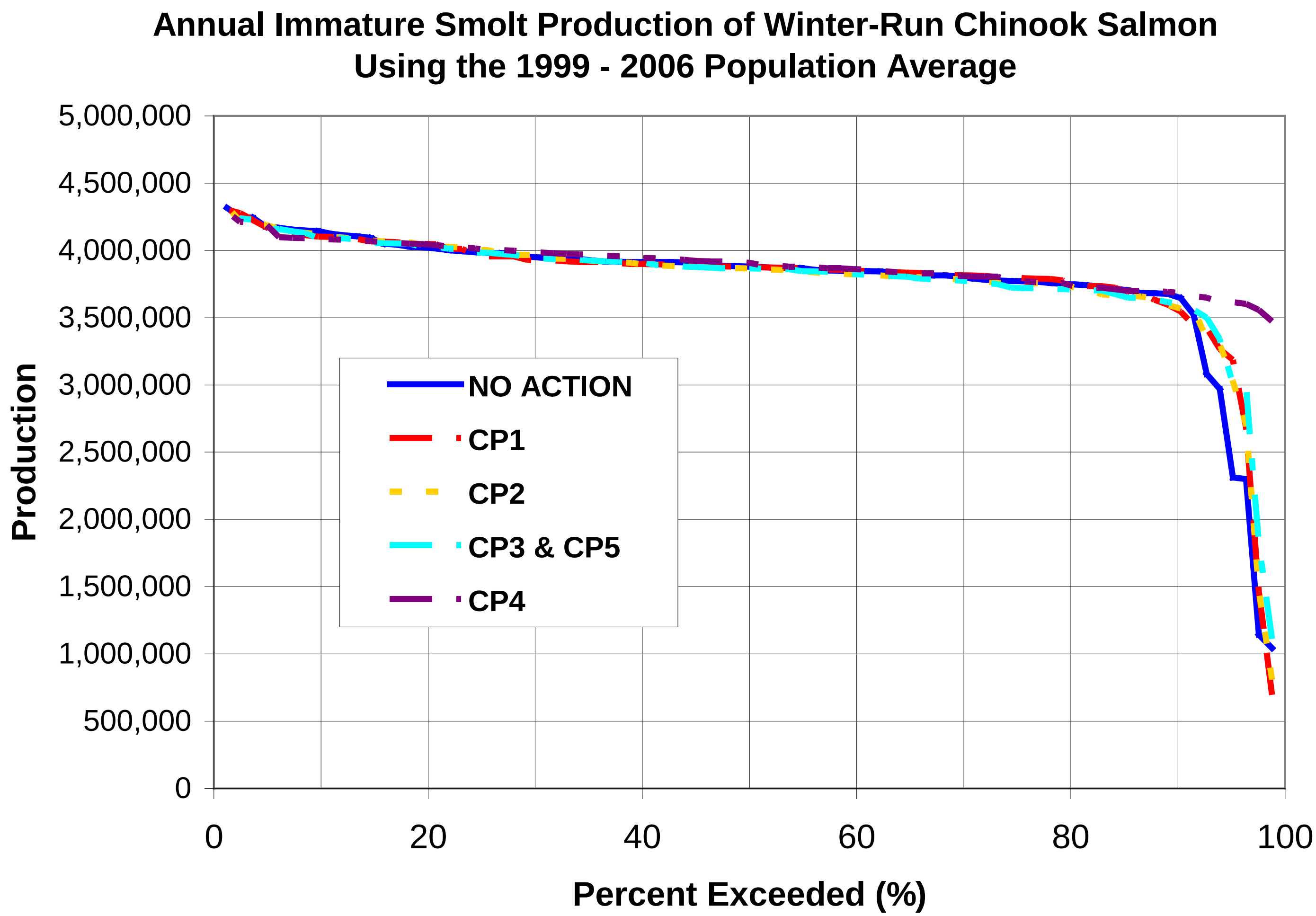

Figure 8A. Frequency distribution of annual immature smolt production of winter-run Chinook salmon in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam (RBDD) using the 1999 – 2006 population average.

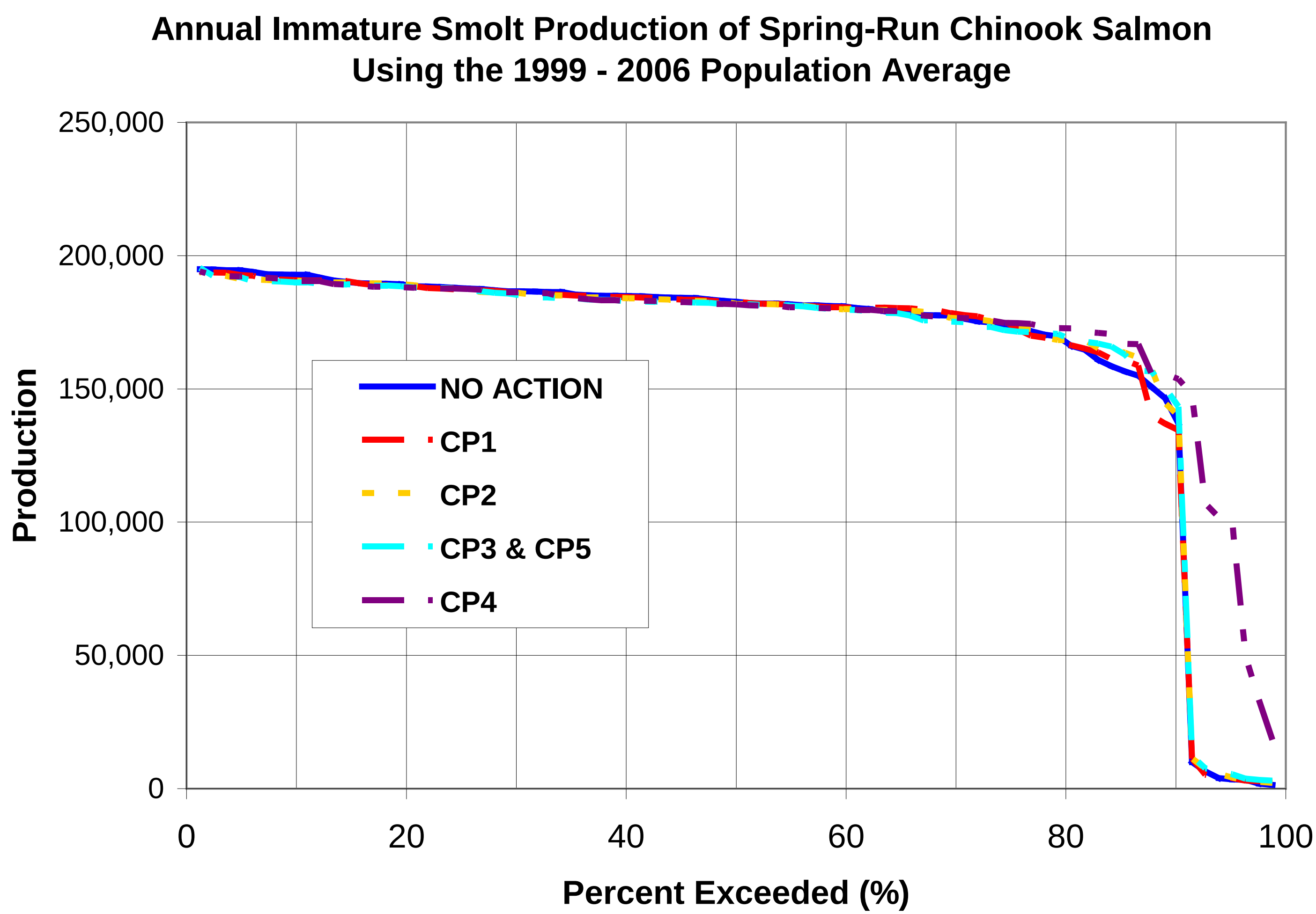

Figure 8B. Frequency distribution of annual immature smolt production of spring-run Chinook salmon in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam (RBDD) using the 1999 – 2006 population average.

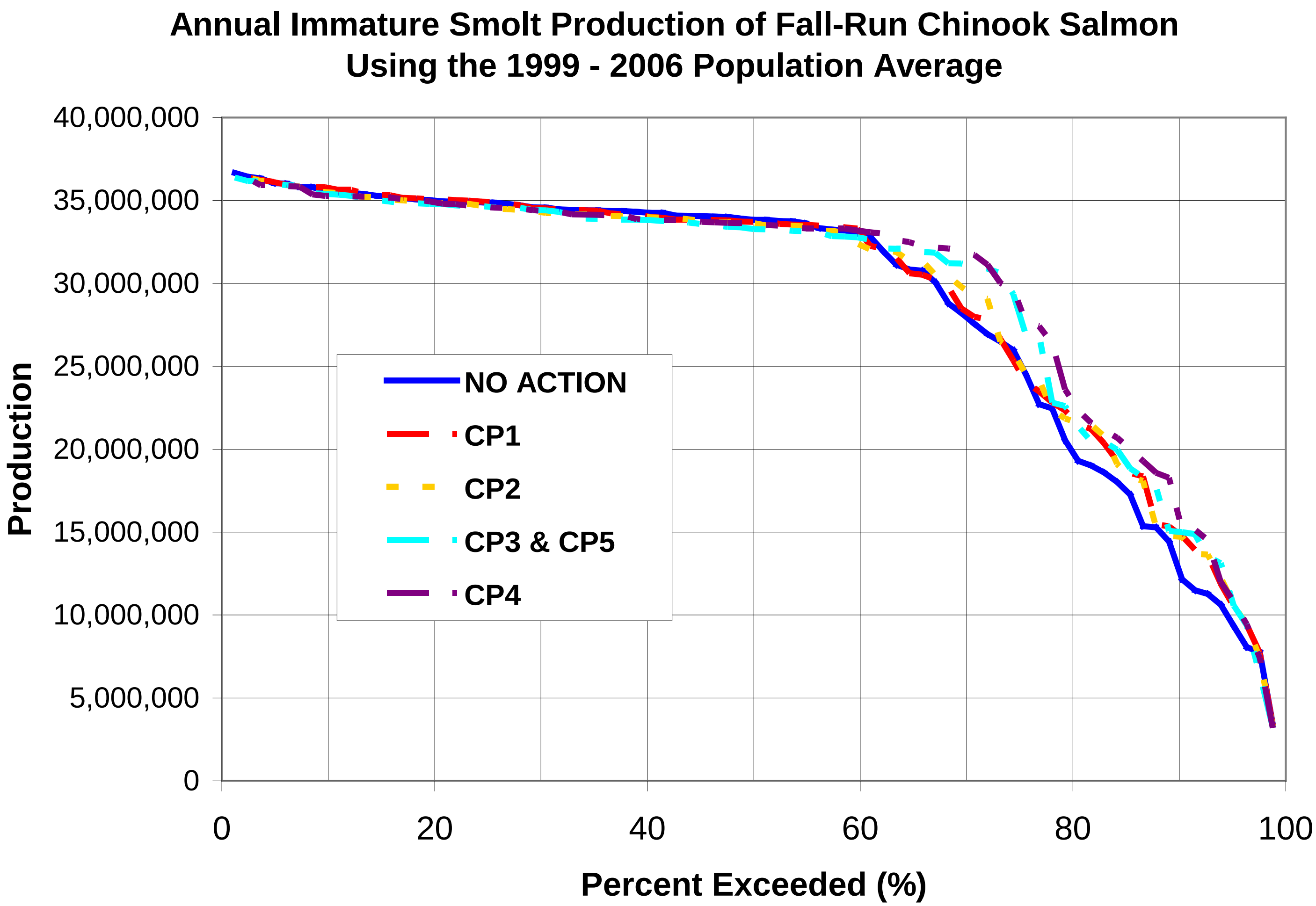

Figure 8C. Frequency distribution of annual immature smolt production of fall-run Chinook salmon in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam (RBDD) using the 1999 – 2006 population average.

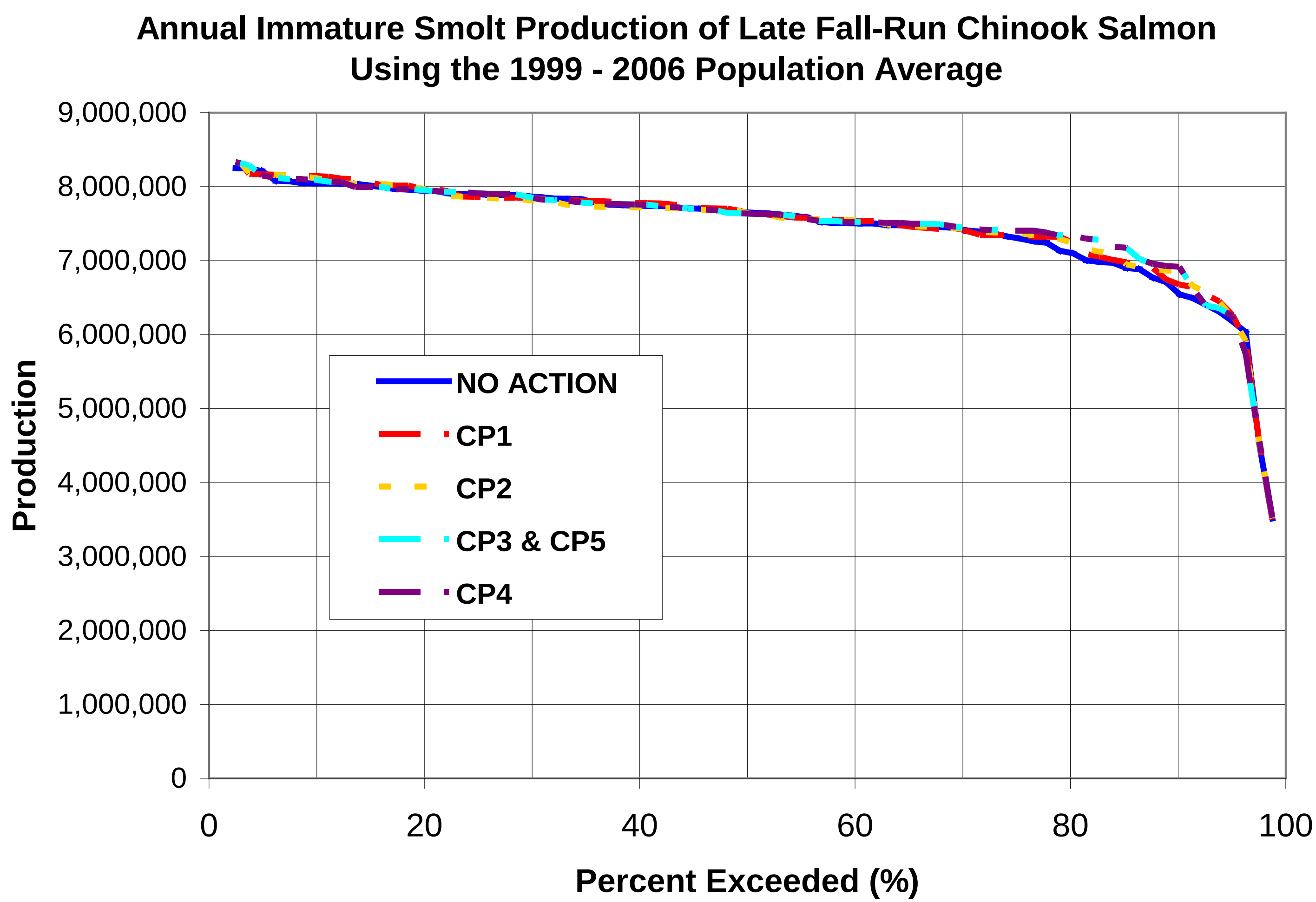

Figure 8D. Frequency distribution of annual immature smolt production of late fall-run Chinook salmon in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam (RBDD) using the 1999 – 2006 population average.

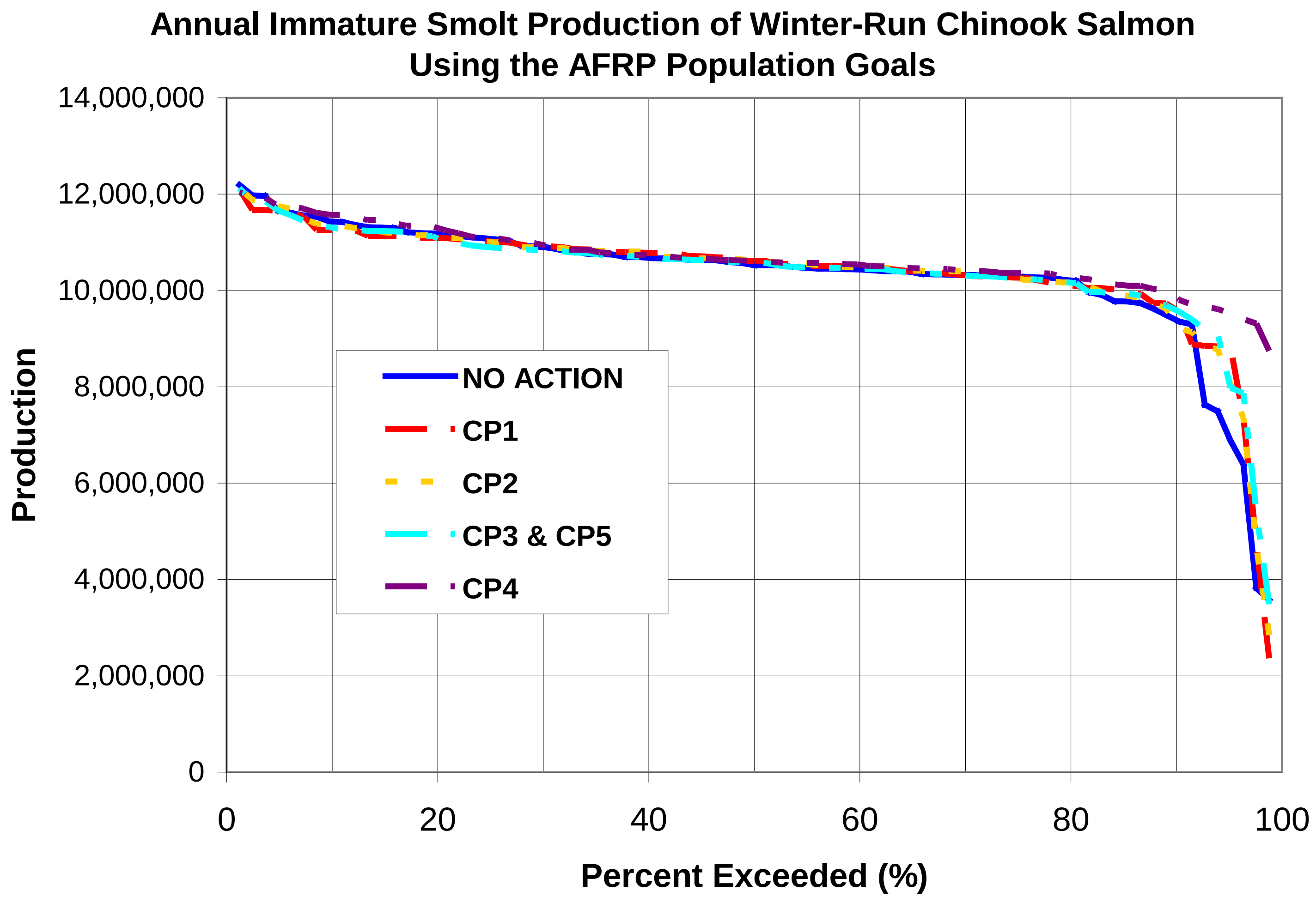

Figure 9A. Frequency distribution of annual immature smolt production of winter-run Chinook salmon in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam (RBDD) using the AFRP population goals.

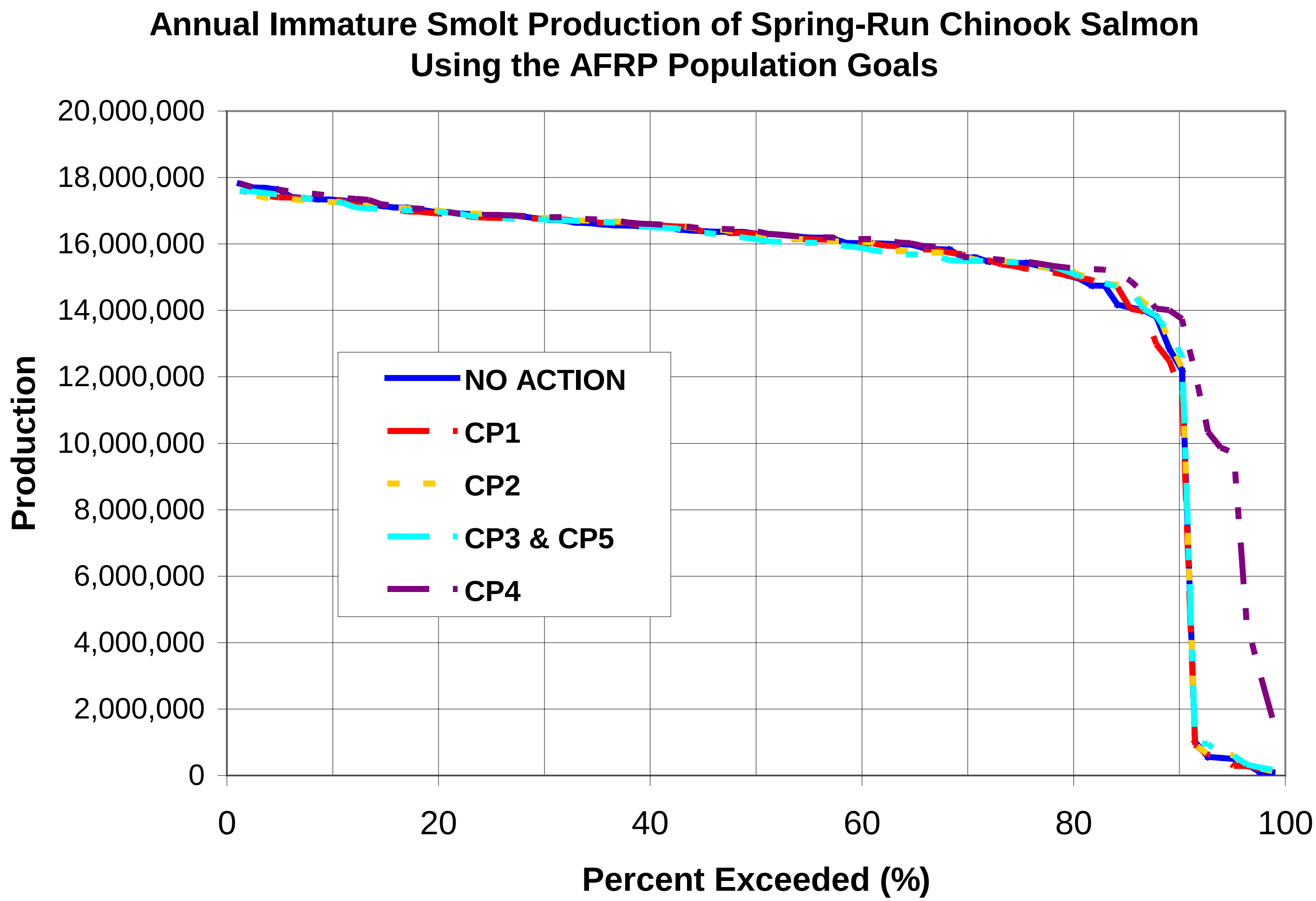

Figure 9B. Frequency distribution of annual immature smolt production of spring-run Chinook salmon in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam (RBDD) using the AFRP population goals.

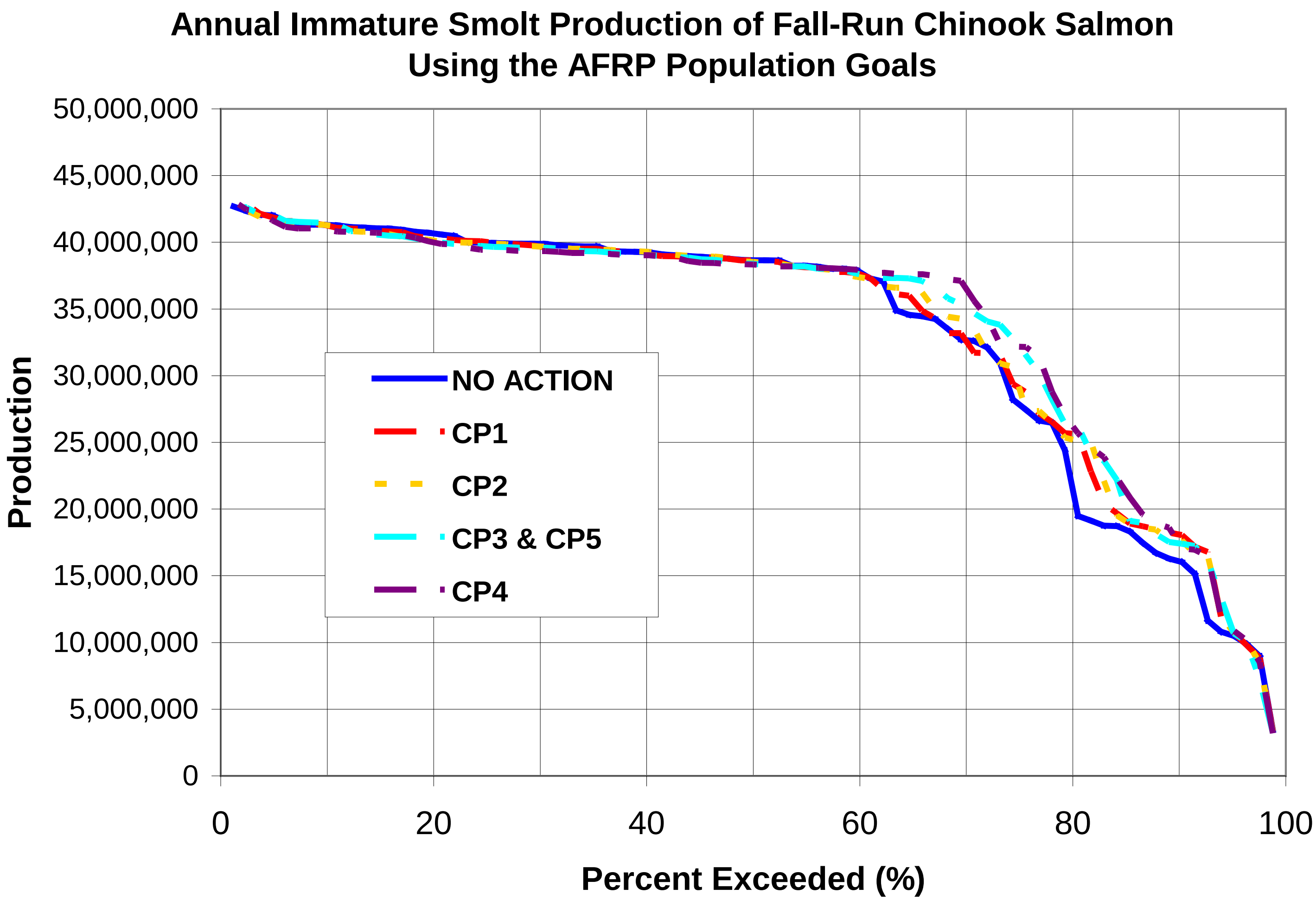

Figure 9C. Frequency distribution of annual immature smolt production of fall-run Chinook salmon in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam (RBDD) using the AFRP population goals.

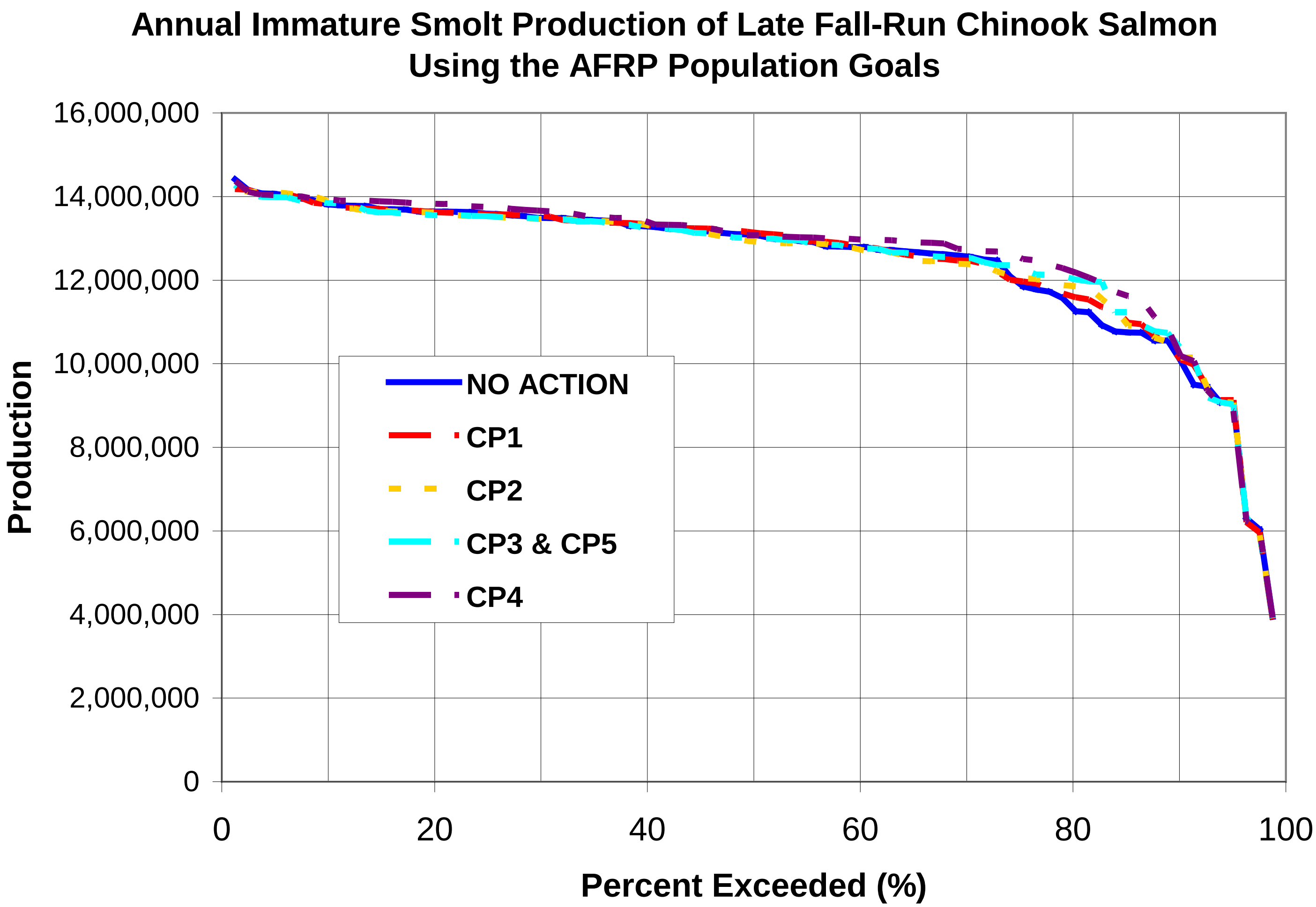

Figure 9D. Frequency distribution of annual immature smolt production of late fall-run Chinook salmon in the Sacramento River between Keswick Dam and the Red Bluff Diversion Dam (RBDD) using the AFRP population goals.

Below is a discussion of the changes in production of winter-, spring-, fall-, and late fall-run Chinook salmon immature smolts in each of the SLWRI alternatives relative to the No Action Alternative. However, it should be noted that Salmod modeling likely underestimates the mortality of Chinook salmon eggs, fry, pre-smolts and immature smolts: (1) due to the inability of Salmod to model resource competition among the four runs of Chinook salmon and steelhead; and (2) by limiting the simulation to areas upstream of the RBDD where mortality rates are considerably lower than further downstream. Graphs and a more detailed discussion of the sources of mortality to eggs, fry, pre-smolts, and immature smolts for each of the four Chinook salmon runs is provided for No Action and the SLWRI alternatives in Appendix B of this report. Steelhead trout and green sturgeon were not modeled using Salmod; therefore, the analysis of impacts to these species is more qualitative.

<u>Winter-run Chinook Salmon</u>

An analysis of the results from the Salmod modeling is provided below. A more detailed analysis of the effects of the SLWRI on winter-run Chinook salmon will be provided by NOAA Fisheries in Section 7 consultation under ESA.

CP1 – 6.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of winter-run Chinook salmon in CP1 increased by 17,609 (0.5 percent) relative to No Action, but the median annual immature smolt production decreased by 4,940 (-0.1 percent). In 75 percent of the years simulated (61 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8A). In 15 percent of the years simulated (12 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 5 percent of the years simulated (4 of 81 years) the increase was greater than 10 percent. In 10 percent of the years simulated (8 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 1 percent of the years simulated (1 of 81 years), the decrease was greater than 10 percent. CP1 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1924, 1931, 1933 and 1934. These significant increases in production in CP1 occurred during low production years when immature smolt production in the No Action Alternative was in the tenth lowest percentile. CP1 had a significant decrease in immature smolt production during the critical water year 1977 when immature smolt production decreased by 39 percent from 1,142,239 in the No Action to 696,413 in CP1; this occurred following two consecutive critical water years. In summary, CP1 had significant (greater than 10 percent) increases in immature smolt production of winter-run Chinook salmon relative to No Action during 4 out of 13 critical water years during the 1922 – 2002 period of simulation, but CP1 also had a significant decrease in immature smolt production during one critical water year.

Using the AFRP population goals, average annual immature smolt production of winter-run Chinook salmon in CP1 increased by 65,532 (0.6 percent) relative to No Action, and the median annual immature smolt production increased by 73,498 (0.7 percent). In 46 percent of the years simulated (37 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9A). In 31 percent of the years simulated (25 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 6 percent of the years simulated (5 of 81 years) the increase was greater than 10 percent. In 23 percent of the years simulated (19 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 2 percent of the years simulated (2 of 81 years), the decrease was greater than 10 percent. CP1 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1924, 1931, 1933, 1934, and 1992. These significant increases in production in CP1 occurred during low production years when immature smolt production in the No Action Alternative was in the seventh lowest percentile. CP1 had a significant decrease in immature smolt production during the critical water year 1977 and the wet water year 1927. In 1977, immature smolt production decreased by 34 percent from 3,577,217 in the No Action to 2,366,660 in CP1; this occurred following two consecutive critical water years. In summary, using the AFRP population goals, CP1 had significant (greater than 10 percent) increases in immature smolt production of winter-run Chinook salmon relative to No Action during 5 out of 13 critical water years during the 1922 – 2002 period of simulation, but CP1 also had significant decreases in immature smolt production during one critical water year and one wet water year.

CP2 – 12.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of winter-run Chinook salmon in CP2 increased by 9,914 (0.3 percent) relative to No Action, but the median annual immature smolt production decreased by 23,685 (-0.6 percent). In 81 percent of the years simulated (66 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8A). In 14 percent of the years simulated (11 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 4 percent of the years simulated (3 of 81 years), the increase was greater than 10 percent. In 15 percent of the years simulated (12 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 1 percent of the years simulated (1 of 81 years), the decrease was greater than 10 percent. CP2 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1924, 1931, and 1934. These significant increases in production in CP2 occurred during low production years when immature smolt production in the No Action Alternative was in the tenth lowest percentile. CP2 had a significant decrease in immature smolt production during the critical water year 1977 when immature smolt production decreased by 29 percent from 1,142,239 in the No Action to 809,434 in CP2; this occurred following a critical water year in 1976. In summary, CP2 had significant increases (greater than 10 percent) in immature smolt production of winter-run Chinook salmon relative to No Action during 3 out of 13 critical water years over the 1922 – 2002 period of simulation.

Using the AFRP population goals, average annual immature smolt production of winter-run Chinook salmon in CP2 increased by 72,399 (0.7 percent) relative to No Action, and the median annual immature smolt production increased by 6,990 (0.07 percent). In 54 percent of the years simulated (44 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9A). In 27 percent of the years simulated (22 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 6 percent of the years simulated (5 of 81 years), the increase was greater than 10 percent. In 21 percent of the years simulated (17 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 2 percent of the years simulated (2 of 81 years), the decrease was greater than 10 percent. CP2 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1924, 1931, 1933, 1934, and 1992. These significant increases in production in CP2 occurred during low production years when immature smolt production in the No Action Alternative was in the seventh lowest percentile. CP1 had a significant decrease in immature smolt production during the critical water year 1977 and the wet water year 1927. In 1977, immature smolt production decreased by 20 percent from 3,577,217 in the No Action to 2,851,277 in CP2; this occurred following two consecutive critical water years. In summary, using the AFRP population goals, CP2 had significant (greater than 10 percent) increases in immature smolt production of winter-run Chinook salmon relative to No Action during 5 out of 13 critical water years during the 1922 – 2002 period of simulation, but CP1 also had significant decreases in immature smolt production during one critical water year and one wet water year.

CP3 and CP5 – 18.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of winter-run Chinook salmon in CP3 and CP5 increased by 19,141 (0.5 percent) relative to No Action, but the median annual immature smolt production decreased by 16,923 (-0.4 percent). In 70 percent of the years simulated (57 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8A). In 12 percent of the years simulated (10 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 5 percent of the years simulated (4 of 81 years), the increase was greater than 10 percent. In 17 percent of the years simulated (14 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never more than 4 percent. CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1924, 1931, 1933, and 1934. These significant increases in production in CP3 and CP5 occurred during low production years when immature smolt production in the No Action Alternative was in the tenth lowest percentile. However, in 17 percent of the years simulated (14 out of 81 years) immature smolt production decreased by 2 – 4 percent relative to No Action; this decrease occurred during seven wet water years, four below normal water years, two critical water years, and one above normal water year. In summary, CP3 and CP5 had significant increases (greater than 10 percent) in immature smolt production of winter-run Chinook salmon relative to No Action during 4 out of 13 critical water years over the 1922 – 2002 period of simulation.

Using the AFRP population goals, average annual immature smolt production of winter-run Chinook salmon in CP3 and CP5 increased by 73,754 (0.7 percent) relative to No Action, but the median annual immature smolt production decreased by 3,475 (-0.03 percent). In 47 percent of the years simulated (38 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9A). In 26 percent of the years simulated (21 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 5 percent of the years simulated (4 of 81 years), the increase was greater than 10 percent. In 27 percent of the years simulated (22 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never more than 8 percent. CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1924, 1931, 1933, and 1934. These significant increases in production in CP3 and CP5 occurred during low production years when immature smolt production in the No

Action Alternative was in the seventh lowest percentile. In summary, using the AFRP population goals, CP3 and CP5 had significant increases (greater than 10 percent) in immature smolt production of winter-run Chinook salmon relative to No Action during 4 out of 13 critical water years over the 1922 – 2002 period of simulation; however, immature smolt production decreased by 2 – 8 percent during 27 percent of the years simulated.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus

Using the 1999 – 2006 population average, average annual immature smolt production of winter-run Chinook salmon in CP4 increased by 117,451 (3.1 percent) relative to No Action, but the median annual immature smolt production decreased by 24,811 (-0.6 percent). In 59 percent of the years simulated (48 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8A). In 19 percent of the years simulated (15 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 9 percent of the years simulated (7 of 81 years), the increase was greater than 10 percent. In 22 percent of the years simulated (18 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never more than 5 percent. CP4 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1924, 1931, 1933, 1934, 1977, and 1992 and the dry water year 1932. These significant increases in production in CP4 occurred during low production years when immature smolt production in the No Action Alternative was in the tenth lowest percentile. However, in 22 percent of the years simulated (18 out of 81 years) immature smolt production decreased by 2 – 5 percent relative to No Action; this decrease occurred during 12 wet water years, three below normal water years, two critical water years, and one dry water year. In summary, CP4 had significant increases (greater than 10 percent) in immature smolt production of winter-run Chinook salmon relative to No Action during 7 out of 13 critical water years and 1 out of 17 dry water years over the 1922 – 2002 period of simulation; however, immature smolt production decreased by 2 – 5 percent relative to No Action during 22 percent of the years simulated.

Using AFRP population goals, average annual immature smolt production of winter-run Chinook salmon in CP4 increased by 354,880 (3.4 percent) relative to No Action, and the median annual immature smolt production increased by 40,500 (0.4 percent). In 40 percent of the years simulated (32 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9A). In 38 percent of the years simulated (31 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 10 percent of the years simulated (8 of 81 years), the increase was greater than 10 percent. In 22 percent of the years simulated (18 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 1 percent of the years simulated (1 of 81 years), the increase was greater than 10 percent. CP4 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1924, 1931, 1933, 1934, 1977, 1988, and 1992 and the dry water year 1932. These significant increases in production in CP4 occurred during low production years when immature smolt production in the No Action Alternative was in the thirty-second lowest percentile. CP4 had a significant decrease in immature smolt production during the wet water year 1927 when production decreased by 15 percent from 10,341,626 in No Action to 8,748,944 in CP4. In summary, using the AFRP production goals, CP4 had significant increases (greater than 10 percent) in immature smolt production of winter-run Chinook salmon relative to No Action during 7 out of 13 critical water years and 1 out of 17 dry water years over the 1922 – 2002 period of simulation; however, immature smolt production decreased by 15 percent during one wet water year.

Spring-run Chinook Salmon

An analysis of the results from the Salmod modeling is provided below. A more detailed analysis of the effects of the SLWRI on spring-run Chinook salmon will be provided by NOAA Fisheries in Section 7 consultation under ESA.

CP1 – 6.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of spring-run Chinook salmon in CP1 decreased by 289 (-0.2 percent) relative to No Action, and the median annual immature smolt production decreased by 154 (-0.1 percent). In 78 percent of the years simulated (63 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8B). In 15 percent of the years simulated (12 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 6 percent of the years simulated (5 of 81 years) the increase was greater than 10 percent. In 9 percent of the years simulated (7 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 2 percent of the years simulated (2 of 81 years), the decrease was greater than 10 percent. CP1 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1924, 1931, 1933 and 1977 and the dry water year 1932. These significant increases in production in CP1 occurred during low production years when immature smolt production in the No Action Alternative was in the tenth lowest percentile. CP1 had significant decreases in immature smolt production relative to No Action during critical water years 1934 and 1992 following six consecutive years of drought in 1929 – 1934 and 1987 – 1992, respectively. In 1934, immature smolt production decreased by 15 percent from 3,297 in the No Action to 2,791 in CP1. In 1992, immature smolt production decreased by 39 percent from 6,513 in the No Action to 3,956 in CP1. In summary, CP1 had significant (greater than 10 percent) increases in immature smolt production of spring-run Chinook salmon relative to No Action during 4 out of 13 critical water years and 1 out of 17 dry water years during the 1922 – 2002 period of simulation, but CP1 also had a significant decrease in immature smolt production during two critical water years.

Using the AFRP population goals, average annual immature smolt production of spring-run Chinook salmon in CP1 decreased by 47,484 (-0.3 percent) relative to No Action, and the median annual immature smolt production decreased by 31,099 (-0.2 percent). In 63 percent of the years simulated (51 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9B). In 14 percent of the years simulated (11 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 5 percent of the years simulated (4 of 81 years) the increase was greater than 10 percent. In 24 percent of the years simulated (19 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 2 percent of the years simulated (2 of 81 years), the decrease was greater than 10 percent. CP1 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1931, 1933, and 1977 and the dry water year 1932. These significant increases in production in CP1 occurred during low production years when immature smolt production in the No Action Alternative was in the eight lowest percentile. CP1 had significant decreases in immature smolt production relative to No Action during critical water years 1934 and 1992 following six consecutive years of drought in 1929 – 1934 and 1987 – 1992, respectively. In 1934, immature smolt production decreased by 13 percent from 334,642 in the No Action to 289,800 in CP1. In 1992, immature smolt production decreased by 48 percent from 532,581 in the No Action to 279,838 in CP1. In summary, using the AFRP population goals, CP1 had significant (greater than 10 percent) increases in immature smolt production of spring-run Chinook salmon relative to No Action during 3 out of 13 critical water years and 1 out of 17 dry water years during the 1922 – 2002 period of simulation, but CP1 also had a significant decrease in immature smolt production during two critical water years.

CP2 – 12.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of spring-run Chinook salmon in CP2 increased by 29 (0.02 percent) relative to No Action, but the median annual immature smolt production decreased by 692 (-0.4 percent). In 73 percent of the years simulated (59 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8B). In 20 percent of the years simulated (16 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 9 percent of the years simulated (7 of 81 years) the increase was greater than 10 percent. In 10 percent of the years simulated (8 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 1 percent of the years simulated (1 of 81 years), the decrease was greater than 10 percent. CP2 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1924, 1931, 1933, 1977, 1992, and 1994 and the dry water year 1932. These significant increases in production in CP2 occurred during low production years when immature smolt production in the No Action Alternative was in the thirteenth lowest percentile. CP2 had a significant decrease in immature smolt production relative to No Action during the critical water year 1934 following six consecutive years of drought. In 1934, immature smolt production decreased by 35 percent from 3,297 in the No Action to 2,161 in CP2. In summary, CP2 had significant (greater than 10 percent) increases in immature smolt production of spring-run Chinook salmon relative to No Action during 6 out of 13 critical water years and 1 out of 17 dry water years during the 1922 – 2002 period of simulation, but CP2 also had a significant decrease in immature smolt production during one critical water year.

Using the AFRP population goals, average annual immature smolt production of spring-run Chinook salmon in CP2 increased by 12,553 (0.08 percent) relative to No Action, but the median annual immature smolt production decreased by 42,246 (-0.3 percent). In 63 percent of the years simulated (51 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9B). In 21 percent of the years simulated (17 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 7 percent of the years simulated (6 of 81 years) the increase was greater than 10 percent. In 16 percent of the years simulated (13 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 1 percent of the years simulated (1 of 81 years), the decrease was greater than 10 percent. CP2 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1931, 1933, 1977, 1992, and 1994 and the dry water year 1932. These significant increases in production in CP2 occurred during low production years when immature smolt production in the No Action Alternative was in the sixteenth lowest percentile. CP2 had a significant decrease in immature smolt production relative to No Action during the critical water year 1934 following six consecutive years of drought. In 1934, immature smolt production decreased by 33 percent from 334,642 in the No Action to 225,870 in CP2. In summary, using the AFRP production goals, CP2 had significant (greater than 10 percent) increases in immature smolt production of spring-run Chinook salmon relative to No Action during 5 out of 13 critical water years and 1 out of 17 dry water years during the 1922 – 2002 period of simulation, but CP2 also had a significant decrease in immature smolt production during one critical water year.

CP3 and CP5 – 18.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of spring-run Chinook salmon in CP3 and CP5 decreased by 357 (-0.2 percent) relative to No Action, and the median annual immature smolt production decreased by 1,156 (-0.6 percent). In 53 percent of the years simulated (43 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8B). In 23 percent of the years simulated (19 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 7 percent of the years simulated (6 of 81 years) the increase was greater than 10 percent. In 23 percent of the years simulated (19 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never more than 8 percent. CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1924, 1931, 1933, 1977, and 1994 and the dry water year 1932. These significant increases in production in CP3 and CP5 occurred during low production years when immature smolt production in the No Action Alternative was in the thirteenth lowest percentile. In summary, CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production of spring-run Chinook salmon relative to No Action during 5 out of 13 critical water years and 1 out of 17 dry water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 8 percent during 23 percent of the years simulated.

Using the AFRP population goals, average annual immature smolt production of spring-run Chinook salmon in CP3 and CP5 decreased by 23,723 (-0.2 percent) relative to No Action, and the median annual immature smolt production decreased by 67,794 (-0.4 percent). In 56 percent of the years simulated (45 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8B). In 23 percent of the years simulated (19 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 7 percent of the years simulated (6 of 81 years) the increase was greater than 10 percent. In 21 percent of the years simulated (17 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never more than 8 percent. CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1931, 1933, 1977, 1992, and 1994 and the dry water year 1932. These significant increases in production in CP3 and CP5 occurred during low production years when immature smolt production in the No Action Alternative was in the sixteenth lowest percentile. In summary, using AFRP population goals, CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production of spring-run Chinook salmon relative to No Action during 5 out of 13 critical water years and 1 out of 17 dry water years during the 1922 –

2002 period of simulation. However, immature smolt production decreased by 2 – 8 percent during 21 percent of the years simulated.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus

Using the 1999 – 2006 population average, average annual immature smolt production of spring-run Chinook salmon in CP4 increased by 7,023 (4.2 percent) relative to No Action, but the median annual immature smolt production decreased by 1,905 (-1.0 percent). In 49 percent of the years simulated (40 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8B). In 21 percent of the years simulated (17 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 11 percent of the years simulated (9 of 81 years) the increase was greater than 10 percent. In 30 percent of the years simulated (24 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 10 percent. CP4 had significant (greater than 10 percent) increases in immature smolt production during the following water year types: the critical water years 1924, 1931, 1933, 1934, 1977, 1988, 1991, 1992, and 1994; the dry water years 1925, 1926, and 1932; and the below normal water year 1935. These significant increases in production in CP4 occurred during low production years when immature smolt production in the No Action Alternative was in the twenty-fourth lowest percentile. In summary, CP4 had significant (greater than 10 percent) increases in immature smolt production of spring-run Chinook salmon relative to No Action during 9 out of 13 critical water years, 3 out of 17 dry water years, and 1 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 10 percent during 26 percent of the years simulated.

Using the AFRP population goals, average annual immature smolt production of spring-run Chinook salmon in CP4 increased by 732,542 (4.9 percent) relative to No Action, but the median annual immature smolt production decreased by 68,763 (-0.4 percent). In 46 percent of the years simulated (37 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9B). In 30 percent of the years simulated (24 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 15 percent of the years simulated (12 of 81 years) the increase was greater than 10 percent. In 25 percent of the years simulated (20 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 9 percent. CP4 had significant (greater than 10 percent) increases in immature smolt production during the following water year types: the critical water years 1924, 1931, 1933, 1934, 1977, 1988, 1991, and 1992; the dry water years 1925, 1926, and 1932; and the below normal water year 1935. These significant increases in production in CP4 occurred during low and moderate production years when immature smolt production in the No Action Alternative was in the forty-first lowest percentile. In summary, using the AFRP production goals, CP4 had significant (greater than 10 percent) increases in immature smolt production of spring-run Chinook salmon relative to No Action during 8 out of 13 critical water years, 3 out of 17 dry water years, and 1 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 9 percent during 25 percent of the years simulated.

Fall-run Chinook Salmon

CP1 – 6.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of fall-run Chinook salmon in CP1 increased by 337,274 (1.2 percent) relative to No Action, and the median annual immature smolt production increased by 47,557 (0.1 percent). In 74 percent of the years simulated (60 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8C). In 20 percent of the years simulated (16 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 6 percent of the years simulated (5 of 81 years) the increase was greater than 10 percent. In 9 percent of the years simulated (7 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 7 percent. CP1 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1931, 1934 and 1977 and the below normal water years 1937 and 1945. These significant increases in production in CP1 occurred during low production years when immature smolt production in the No Action Alternative was in the eighteenth lowest percentile. In summary, CP1 had significant (greater than 10 percent) increases in immature smolt production of fall-run Chinook salmon relative to No Action during 3 out of 13 critical water years and 2 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 7 percent during 9 percent of the years simulated.

Using the AFRP population goals, average annual immature smolt production of fall-run Chinook salmon in CP1 increased by 381,227 (1.2 percent) relative to No Action, but the median annual immature smolt production decreased by 3,185 (-0.01 percent). In 53 percent of the years simulated (43 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9C). In 27 percent of the years simulated (22 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 6 percent of the years simulated (5 of 81 years) the increase was greater than 10 percent. In 20 percent of the years simulated (16 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 1 percent of the years simulated (1 out of 81 years), the decrease was greater than 10 percent. CP1 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1931, 1934 and 1977 and the below normal water years 1937 and 1945. These significant increases in production in CP1 occurred during low production years when immature smolt production in the No Action Alternative was in the eighteenth lowest percentile. CP1 had a significant decrease in immature smolt production during the critical water year 1992 following six consecutive years of drought. In 1992, immature smolt production decreased by 10 percent from 38,248,592 in the No Action to 34,307,600 in CP1. In summary, using the AFRP population goals, CP1 had significant (greater than 10 percent) increases in immature smolt production of fall-run Chinook salmon relative to No Action during 3 out of 13 critical water years and 2 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 10 percent during one critical water year during the simulation period.

CP2 – 12.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of fall-run Chinook salmon in CP2 increased by 303,427 (1.0 percent) relative to No Action, but the median annual immature smolt production decreased by 37,957 (-0.1 percent). In 59 percent of the years simulated (48 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8C). In 21 percent of the years simulated (17 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 5 percent of the years simulated (4 of 81 years) the increase was greater than 10 percent. In 20 percent of the years simulated (16 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 9 percent. CP2 had significant (greater than 10 percent) increases in immature smolt production during the critical water years 1931, 1934, and 1977 and the below normal water year 1945. These significant increases in production in CP2 occurred during low production years when immature smolt production in the No Action Alternative was in the fifteenth lowest percentile. In summary, CP2 had significant (greater than 10 percent) increases in immature smolt production of fall-run Chinook salmon relative to No Action during 3 out of 13 critical water years and 1 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 9 percent during 20 percent of the years simulated.

Using the AFRP population goals, average annual immature smolt production of fall-run Chinook salmon in CP2 increased by 430,452 (1.3 percent) relative to No Action, and the median annual immature smolt production increased by 9,964 (0.03 percent). In 52 percent of the years simulated (42 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9C). In 28 percent of the years simulated (23 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 7 percent of the years simulated (6 of 81 years) the increase was greater than 10 percent. In 20 percent of the years simulated (16 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 6 percent. CP2 had significant (greater than 10 percent) increases in immature smolt production during the following water year types: the critical water years 1931, 1934, and 1977; the dry water year 1964; and the below normal water years 1937 and 1945. These significant increases in production in CP2 occurred during low production years when immature smolt production in the No Action Alternative was in the twenty-fourth lowest percentile. In summary, using the AFRP population goals, CP2 had significant (greater than 10 percent) increases in immature smolt production of fall-run Chinook salmon relative to No Action during 3 out of 13 critical water years, 1 out of 17 dry water years, and 1 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 6 percent during 20 percent of the years simulated.

CP3 and CP5 – 18.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of fall-run Chinook salmon in CP3 and CP5 increased by 566,410 (2.0 percent) relative to No Action, but the median annual immature smolt production decreased by 166,866 (-0.5 percent). In 49 percent of the years simulated (40 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8C). In 21 percent of the years simulated (17 of

81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 11 percent of the years simulated (9 of 81 years) the increase was greater than 10 percent. In 20 percent of the years simulated (16 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 1 percent of the years simulated (1 of 81 years) the decrease was greater than 10 percent. CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production during the following water year types: the critical water years 1931, 1933, and 1934; the dry water years 1926, 1932, 1939, 1955, and 1964; and the below normal water year 1945. These significant increases in production in CP3 and CP5 occurred during low production years when immature smolt production in the No Action Alternative was in the thirty-first lowest percentile. CP3 and CP5 had a significant decrease in production during the above normal water year 1957 when production decreased by 17 percent from 7,761,968 in No Action to 6,438,915 in CP3 and CP5. In summary, CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production of fall-run Chinook salmon relative to No Action during 3 out of 13 critical water years, 5 out of 17 dry years, and 1 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 17 percent during 20 percent of the years simulated.

Using the AFRP population goals, average annual immature smolt production of fall-run Chinook salmon in CP3 and CP5 increased by 771,689 (2.3 percent) relative to No Action, but the median annual immature smolt production decreased by 129,857 (-0.3 percent). In 48 percent of the years simulated (39 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9C). In 25 percent of the years simulated (20 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 12 percent of the years simulated (10 of 81 years) the increase was greater than 10 percent. In 27 percent of the years simulated (22 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, and in 1 percent of the years simulated (1 of 81 years) the decrease was greater than 10 percent. CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production during the following water year types: the critical water years 1931, 1933, and 1934; the dry water years 1926, 1932, 1939, 1955, and 1964; and the below normal water year 1945. These significant increases in production in CP3 and CP5 occurred during low production years when immature smolt production in the No Action Alternative was in the thirty-fourth lowest percentile. CP3 and CP5 had a significant decrease in production during the above normal water year 1957 when production decreased by 20 percent from 8,977,131 in No Action to 7,208,711 in CP3 and CP5. In summary, using the AFRP population goals, CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production of fall-run Chinook salmon relative to No Action during 3 out of 13 critical water years, 5 out of 17 dry years, and 2 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 20 percent during 27 percent of the years simulated.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus

Using the 1999 – 2006 population average, average annual immature smolt production of fall-run Chinook salmon in CP4 increased by 908,825 (3.1 percent) relative to No Action, but the median annual immature smolt production decreased by 305,762 (-0.9 percent). In 49 percent of the years simulated (40 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8C). In 19 percent of the years simulated (15 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 11 percent of the years simulated (9 of 81 years) the increase was greater than 10 percent. In 32 percent of the years simulated (26 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 9 percent. CP4 had significant (greater than 10 percent) increases in immature smolt production during the following water year types: the critical water years 1924, 1931, 1933, 1934, 1977, and 1992; the dry water year 1932; and the below normal water years 1937 and 1945. These significant increases in production in CP4 occurred during low production years when immature smolt production in the No Action Alternative was in the thirty-fourth lowest percentile. In summary, CP4 had significant (greater than 10 percent) increases in immature smolt production of fall-run Chinook salmon relative to No Action during 6 out of 13 critical water years, 1 out of 17 dry years, and 2 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 9 percent during 32 percent of the years simulated.

Using the AFRP population goals, average annual immature smolt production of fall-run Chinook salmon in CP4 increased by 856,703 (2.6 percent) relative to No Action, but the median annual immature smolt production decreased by 420,447 (-1.1 percent). In 42 percent of the years simulated (34 of 81 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9C). In 21 percent of the years simulated (17 of 81 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 10 percent of the years simulated (8 of 81 years) the increase was greater than 10 percent. In 37 percent of the years simulated (30 of 81 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 9 percent. CP4 had significant (greater than 10 percent) increases in immature smolt production during the following water year types: the critical water years 1924, 1931, 1933, 1934, and 1977; the dry water year 1932; and the below normal water years 1937 and 1945. These significant increases in production in CP4 occurred during low production years when immature smolt production in the No Action Alternative was in the thirty-fourth lowest percentile. In summary, using the AFRP population goals, CP4 had significant (greater than 10 percent) increases in immature smolt production of fall-run Chinook salmon relative to No Action during 5 out of 13 critical water years, 1 out of 17 dry years, and 2 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 9 percent during 37 percent of the years simulated.

Late Fall-run Chinook Salmon

CP1 – 6.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of late fall-run Chinook salmon in CP1 increased by 32,043 (0.4 percent) relative to No Action, and the median annual immature smolt production increased by 7,627 (0.1 percent). In 66 percent of the years simulated (53 of 80 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8D). In 21 percent of the years simulated (17 of 80 years), immature smolt production increased by greater than 2 percent relative to No Action, but the increase was never greater than 6 percent. In 13 percent of the years simulated (10 of 80 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 3 percent. In summary, there was no significant (greater than 10 percent) increase or decrease in late fall-run immature smolt production during the 1922 – 2002 period of simulation; in two-thirds of the years simulated, the change in immature smolt production was less than 2 percent.

Using the AFRP population goals, average annual immature smolt production of late fall-run Chinook salmon in CP1 increased by 29,252 (0.2 percent) relative to No Action, but the median annual immature smolt production decreased by 29,095 (-0.2 percent). In 64 percent of the years simulated (52 of 80 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9D). In 21 percent of the years simulated (17 of 80 years), immature smolt production increased by greater than 2 percent relative to No Action, but the increase was never greater than 8 percent. In 14 percent of the years simulated (11 of 80 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 4 percent. In summary, using the AFRP population goals, there was no significant (greater than 10 percent) increase or decrease in late fall-run immature smolt production during the 1922 – 2002 period of simulation; in nearly two-thirds of the years simulated, the change in immature smolt production was less than 2 percent.

CP2 – 12.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of late fall-run Chinook salmon in CP2 increased by 23,866 (0.3 percent) relative to No Action, and the median annual immature smolt production increased by 1,886 (0.02 percent). In 63 percent of the years simulated (50 of 80 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8D). In 19 percent of the years simulated (15 of 80 years), immature smolt production increased by greater than 2 percent relative to No Action, but the increase was never greater than 8 percent. In 19 percent of the years simulated (15 of 80 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 5 percent. In summary, there was no significant (greater than 10 percent) increase or decrease in late fall-run immature smolt production during the 1922 – 2002 period of simulation.

Using the AFRP population goals, average annual immature smolt production of late fall-run Chinook salmon in CP2 increased by 15,504 (0.1 percent) relative to No Action, but the median annual immature smolt production decreased by 14,885 (-0.1 percent). In 60 percent of the years simulated (49 of 80 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9D). In 21 percent of the years simulated (17 of 80 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 1 percent of the years simulated (1 of 80 years), the increase was greater than 10 percent. In 18 percent of the years simulated (14 of 80 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 7 percent. CP2 had a significant (greater than 10 percent) increase in immature smolt production during the dry water year 1962 when production increased by 12 percent from 10,556,576 in No Action to 11,855,095 in CP2. In summary, using the AFRP population goals, CP2 had a significant (greater than 10 percent) increase in immature smolt production of late fall-run Chinook salmon relative to No Action during 1 out of 17 dry water years, but not during any critical water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 7 percent during 18 percent of the years simulated.

CP3 and CP5 – 18.5-Foot Dam Raise

Using the 1999 – 2006 population average, average annual immature smolt production of late fall-run Chinook salmon in CP3 and CP5 increased by 42,225 (0.6 percent) relative to No Action, and the median annual immature smolt production increased by 19,424 (0.3 percent). In 59 percent of the years simulated (47 of 80 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8D). In 25 percent of the years simulated (20 of 80 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 3 percent of the years simulated (2 out 80 years), the increase was greater than 10 percent. In 16 percent of the years simulated (13 of 80 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 5 percent. CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production during the dry water years 1926 and 1930. These significant increases in production in CP3 and CP5 occurred during low production years when immature smolt production in the No Action Alternative was in the fifteenth lowest percentile. In summary, CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production of late fall-run Chinook salmon relative to No Action during 2 out of 17 dry years but not during any critical water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 5 percent during 16 percent of the years simulated.

Using the AFRP population goals, average annual immature smolt production of late fall-run Chinook salmon in CP3 and CP5 increased by 49,786 (0.4 percent) relative to No Action, but the median annual immature smolt production decreased by 6,543 (-0.05 percent). In 68 percent of the years simulated (54 of 80 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9D). In 18 percent of the years simulated (14 of 80 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 4 percent of the years simulated (3 out 80 years), the increase was greater than 10 percent. In 15 percent of the years simulated (12 of 80 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 6 percent. CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production during the dry water years 1926, 1930, and 1939. These significant increases in production in CP3 and CP5 occurred during low production years when immature smolt production in the No Action Alternative was in the seventeenth lowest percentile. In summary, using the AFRP population goals, CP3 and CP5 had significant (greater than 10 percent) increases in immature smolt production of late fall-run Chinook salmon relative to No Action during 3 out of 17 dry years but not during any critical water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 6 percent during 15 percent of the years simulated.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus

Using the 1999 – 2006 population average, average annual immature smolt production of late fall-run Chinook salmon in CP4 increased by 161,477 (2.2 percent) relative to No Action, and the median annual immature smolt production increased by 81,239 (1.1 percent). In 61 percent of the years simulated (49 of 80 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 8D). In 35 percent of the years simulated (28 of 80 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 6 percent of the years (5 out 80 years) the increase was greater than 10 percent. In 4 percent of the years simulated (3 of 80 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 6 percent. CP4 had significant (greater than 10 percent) increases in immature smolt production during the following water year types: the critical water years 1933, 1976, and 1991; the dry water year 1930; and the below normal water year 1923. These significant increases in production in CP4 occurred during low production years when immature smolt production in the No Action Alternative was in the twenty-fifth lowest percentile. In summary, CP4 had significant (greater than 10 percent) increases in immature smolt production of late fall-run Chinook salmon relative to No Action during 3 out of 13 critical water years, 1 out of 17 dry years, and 1 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 6 percent during 4 percent of the years simulated.

Using the AFRP population goals, average annual immature smolt production of late fall-run Chinook salmon in CP4 increased by 213,604 (1.7 percent) relative to No Action, and the median annual immature smolt production increased by 11,852 (0.09 percent). In 60 percent of the years simulated (48 of 80 years), the change in immature smolt production was less than 2 percent relative to No Action (Figure 9D). In 31 percent of the years simulated (25 of 80 years), immature smolt production increased by greater than 2 percent relative to No Action, and in 5 percent of the years (4 out 80 years) the increase was greater than 10 percent. In 9 percent of the years simulated (7of 80 years), immature smolt production decreased by greater than 2 percent relative to No Action, but the decrease was never greater than 5 percent. CP4 had significant (greater than 10 percent) increases in immature smolt production during the following water year types: the critical water years 1933 and 1976; the dry water year 1930; and the below normal water year 1923. These significant increases in production in CP4 occurred during low production years when immature smolt production in the No Action Alternative was in the twenty-first lowest percentile. In summary, using the AFRP production goals, CP4 had significant (greater than 10 percent) increases in pre- smolt production of late fall-run Chinook salmon relative to No Action during 2 out of 13 critical water years, 1 out of 17 dry years, and 1 out of 14 below normal water years during the 1922 – 2002 period of simulation. However, immature smolt production decreased by 2 – 5 percent during 9 percent of the years simulated.

Steelhead Trout

MWH is currently evaluating qualitatively the effects of the SLWRI alternatives on steelhead. There is not enough information available at this time to adequately evaluate the effects of the SLWRI on steelhead. A more detailed analysis of the effects of the SLWRI on steelhead will be provided by NOAA Fisheries in Section 7 consultation under ESA.

Green Sturgeon

MWH is currently evaluating qualitatively the effects of the SLWRI alternatives on green sturgeon. There is not enough information available at this time to adequately evaluate the effects of the SLWRI on green sturgeon. A more detailed analysis of the effects of the SLWRI on green sturgeon will be provided by NOAA Fisheries in Section 7 consultation under ESA.

Native Resident Fish

The decrease in temperatures in the Sacramento River with the SLWRI alternatives would likely have a negative impact on native resident fish that require warmer temperatures; this includes special-status species such as hardhead and California roach. Optimal temperatures for hardhead are 75-82°F (Knight 1985). Sacramento pikeminnow also prefer warmer water temperatures and rarely thrive below 15°C (59°F) (Moyle 1976). A report from the 1950s stated that cold flows from Shasta Dam had forced Sacramento pikeminnow miles downstream (Taft and Murphy 1950). Therefore, a further decrease in temperatures in the Sacramento River between Keswick Dam and RBDD would also likely cause Sacramento pikeminnow to move downstream.

Special-status Aquatic Species

The effects of the SLWRI on special-status anadromous fish in the Sacramento River between Keswick Dam and the RBDD are discussed in the "Anadromous Fish" section above. A more detailed analysis of the effects of the SLWRI on winter-run Chinook salmon, spring-run Chinook salmon, steelhead, and green sturgeon will be provided by NOAA Fisheries in Section 7 consultation under ESA. A discussion of the sources of mortality for the four runs of Chinook salmon as modeled by Salmod is included in Appendix B of this report. The effects of the SLWRI alternatives on hardhead and California roach are discussed in the "Native Resident Fish" section above.

Terrestrial/Wetland Vegetation and Wildlife

Impacts of the SLWRI alternatives on terrestrial and wetland vegetation and wildlife along the Sacramento River between Keswick Dam and the RBDD is related to changes in the timing, frequency, and duration of flood flows. High frequency flood flows (1 – 4-year flood events) in April – June are important for maintaining and restoring cottonwood and willow riparian habitat in the lower floodplain. Lower frequency flood flows are important for maintaining and restoring oak woodland habitat in the higher floodplain. Spring flood flows are important for the distribution and germination of native riparian vegetation (Little 2007) and for increasing the nest survival rate of black-headed grosbeak (Small 2007). Figure 10 illustrates the frequency distribution of monthly flows in April – June during the period of record in the No Action and SLWRI alternatives. Based on the monthly CALSIM II data, the SLWRI alternatives would result in slight increases in the frequency of April – June 10-year flood events relative to No Action, but would have no significant effect on the frequency of higher frequency flood events.

An analysis of the effects of changes in hydrology on riparian habitat requires data on daily time steps and more complex modeling such as in the Sacramento River Ecological Flows Tool (SacEFT) (ESSA Technologies Ltd. 2006). For instance, the SacEFT evaluates the success of cottonwood seedlings initiating at a given location. Cottonwood seeds are released within a dispersal window (from April 1 to June 30). Dispersal also needs to occur at a relative elevation above base flow within which seeds will not desiccate. While accounting for capillary fringe depth (30-60 cm), rate of stage decline determines soil moisture and the likelihood of desiccation. Hence, for successful germination and initial growth, declines cannot occur at a rate faster than the taproot growth rate (average 22 mm/day, maximum 32 mm/day). The cottonwood performance measure tallies the number of initiation successes and failures across years and across the three cross-sections available on the Sacramento River (ESSA Technologies Ltd. 2006; Roberts *et al.* 2002; Roberts 2003). Thus, a daily model of the Sacramento River (such as SacEFT) is required to adequately evaluate the effects of the SLWRI on riparian habitat.

CP1 – 6.5 Foot Dam Raise

There is not enough information at this time to adequately evaluate the effects of CP1 on riparian habitat.

CP2 – 12.5-Foot Dam Raise

There is not enough information at this time to adequately evaluate the effects of CP2 on riparian habitat.

CP3 – 18.5-Foot Dam Raise

There is not enough information at this time to adequately evaluate the effects of CP3 on riparian habitat. However, hydrological modeling results from disaggregated CALSIM II data (Yaworsky *in litt.* 2007) show a reduction in flood flows by 1,000 – 25,000 cfs during 11 events throughout the 1921 – 2003 period of record. The duration of flood flows also decreased in many instances throughout the period of record. Flood flows are important for the establishment and maintenance of riparian habitat important to sensitive species.

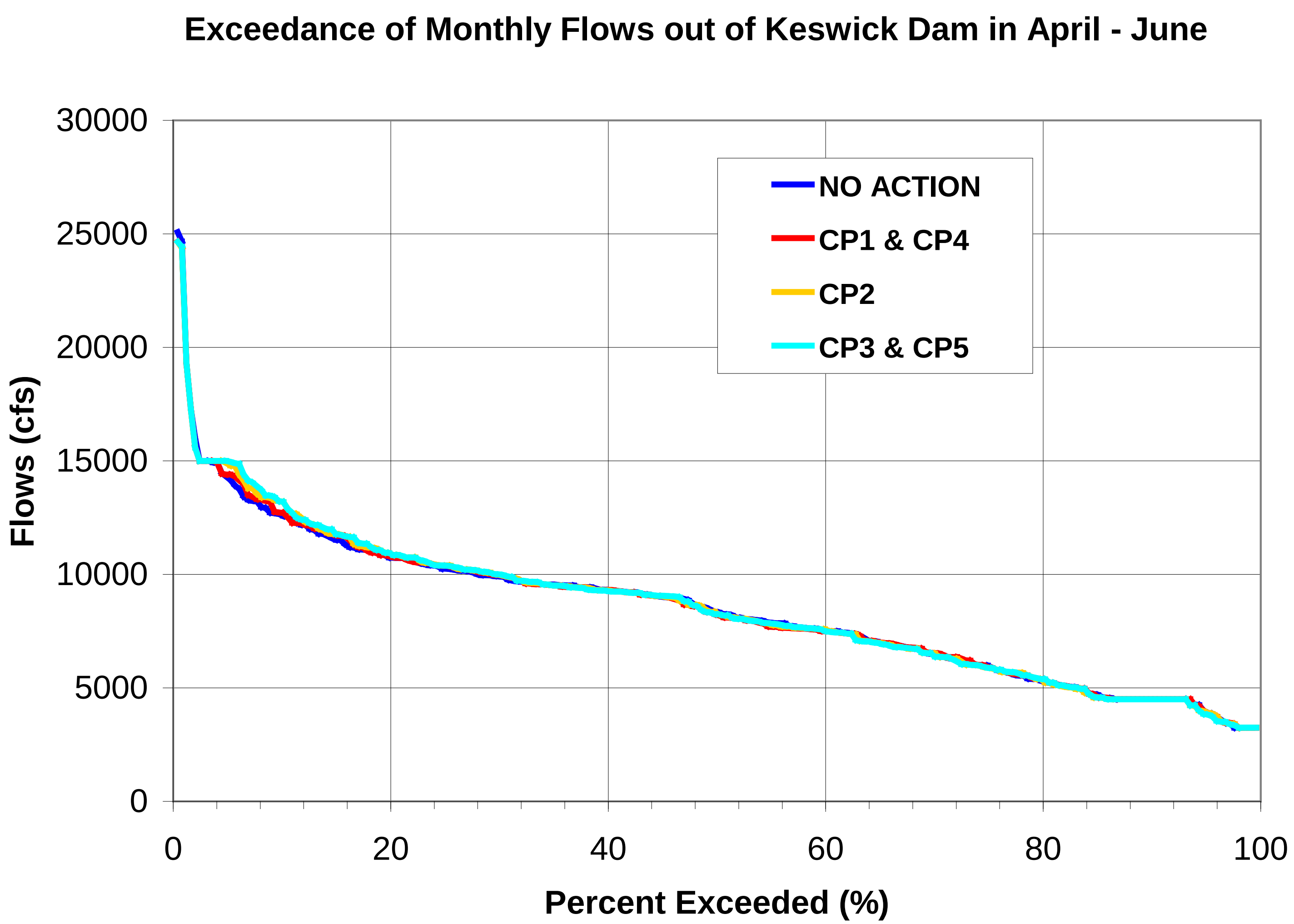

Figure 10. Frequency distribution of monthly April – June flows out of Keswick Dam during the 1921 – 2003 period of record.

Additionally, further decreases in peak flows during the spring would inhibit the regeneration of cottonwoods and willows while potentially promoting the establishment of invasive species.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus

There is not enough information at this time to adequately evaluate the effects of CP4 on riparian habitat. Given the assumption that 378,000 af (or 60 percent of the increased storage from an enlarged Shasta) are held within Shasta Reservoir for cold water storage in CP4, the impacts to terrestrial and wetland habitat along the Sacramento River between Keswick Dam and RBDD would be the same in CP4 as in CP1.

CP5 – 18.5-Foot Dam Raise, Combination Plan

There is not enough information at this time to adequately evaluate the effects of CP5 on riparian habitat. The impacts to terrestrial and wetland habitat along the Sacramento River between Keswick Dam and RBDD would be the same in CP5 as in CP3.

Special-Status Upland and Riparian Species

Changes in the timing, frequency, and duration of flood flows in the SLWRI alternatives would adversely affect the restoration and maintenance of a diversity of riparian habitat important for special-status species such as the valley elderberry longhorn beetle and the yellow-billed cuckoo. There is not enough information available at this time to adequately evaluate the effects of the SLWRI alternatives on riparian habitat for special-status species. A more detailed analysis of the effects of the SLWRI on valley elderberry longhorn beetle and other federally listed species will be provided by the Service in Section 7 consultation under ESA.

Extended Study Area: Sacramento River between RBDD and the Delta

Aquatic Species

The benefits of maintaining cooler water temperatures in the Sacramento River for anadromous fish would most likely be limited to areas upstream of RBDD. However, changes in the timing, frequency, and duration of flows would still occur in the Sacramento River downstream of the RBDD that would likely affect juvenile rearing habitat and adult attraction flows for anadromous fish. A reduction in the frequency and duration of winter and spring flood flows would reduce natural flooding events essential for the establishment of SRA cover. This would reduce suitable juvenile salmonid rearing habitat, increase predator habitat, and affect fish passage. Riparian vegetation is also an important allocthonous source of organic matter and nutrients for the Sacramento River ecosystem (Winemiller and Jepsen 1998). Also, riparian vegetation is essential for terrestrial insects that are an important part of the diet of juvenile salmonids. Studies of the diet and growth rates of fall-run Chinook salmon juveniles in the Sacramento River and Yolo Bypass revealed that dipteran insects associated with woody debris are the preferred diet for juvenile salmonids and contributed to higher growth rates than a diet composed primarily of zooplankton (Sommer *et al.* 2001b).

Figure 11 below compares the frequency distribution of monthly flows in the Sacramento River out of RBDD for the No Action and SLWRI alternatives. The graph shows that there are no significant changes in the frequency and intensity of flood flows or drought flows among the No Action and the SLWRI alternatives. However, the CALSIM output data is for monthly flows and would likely mask any changes in the intensity and duration of flood flows that occur on a daily or weekly time step. Flood flows are ecologically significant for mobilizing bed substrate and the creation of a mix of riparian successional states.

Also important is the timing of flows which is discussed below for each of the alternatives. Spring flood flows also are important for native riparian vegetation establishment (Little 2007) and for decreasing mammalian predator activities that reduce the nesting survival rates of riparian songbirds (Small 2007). The enlarging of Shasta Dam with the SLWRI is likely to result in a further departure from the natural seasonal cycle of flows in the Sacramento River. Figure 8 shows the frequency distribution of the change in monthly flows out of Keswick Dam in the SLWRI alternatives relative to No Action. The graph illustrates that, relative to No Action, the SLWRI alternatives would result in a decrease in monthly flows out of RBDD 10 percent of the time and an increase in monthly flows 15 percent of the time. Therefore, although the SLWRI alternatives may not change the frequency distribution of flows out of RBDD (analyzed on a monthly time step) (Figure 11), they do change the timing of flows out of RBDD relative to No Action (Figure 12).

The next series of graphs, Figures 13A – 13F, compare the average monthly flows out of RBDD by water year type (i.e., wet, above normal, average, below normal, dry, and critical) among the No Action and SLWRI alternatives. Below is a discussion of what effect each of the SLWRI alternatives has on the monthly timing of flows for each water year type.

CP1 – 6.5 Foot Dam Raise

During average water years (Figure 13A), there would be no significant change in the average monthly flows in the Sacramento River downstream from the RBDD in CP1 relative to No Action. During wet water years (Figure 13B), average monthly flows out of the RBDD would decrease by 2 percent (426 cfs) in December. During above normal water years (Figure 13C), average monthly flows out of the RBDD would decrease by 3 percent in January (489 cfs) and March (476 cfs) and by 2 percent in February (547 cfs). During below normal water years (Figure 13D), there would be no significant change in average monthly flows out of the RBDD relative to No Action. During dry water years (Figure 13E), average monthly flows out of the RBDD would decrease by 3 – 4 percent in January, March, and September (278 – 287 cfs) but would increase by 2 – 3 percent in November, June, July, and August (170 – 306 cfs) relative to No Action. The greatest increase in flows would occur during critical water years (Figure 13F) when the average monthly flows out of the RBDD would increase by 16 percent (1,080 cfs) in February to 7,782 cfs compared to 6,702 cfs in the No Action; average monthly flows in September of critical water years would increase by 4 percent (284 cfs) compared to No Action.

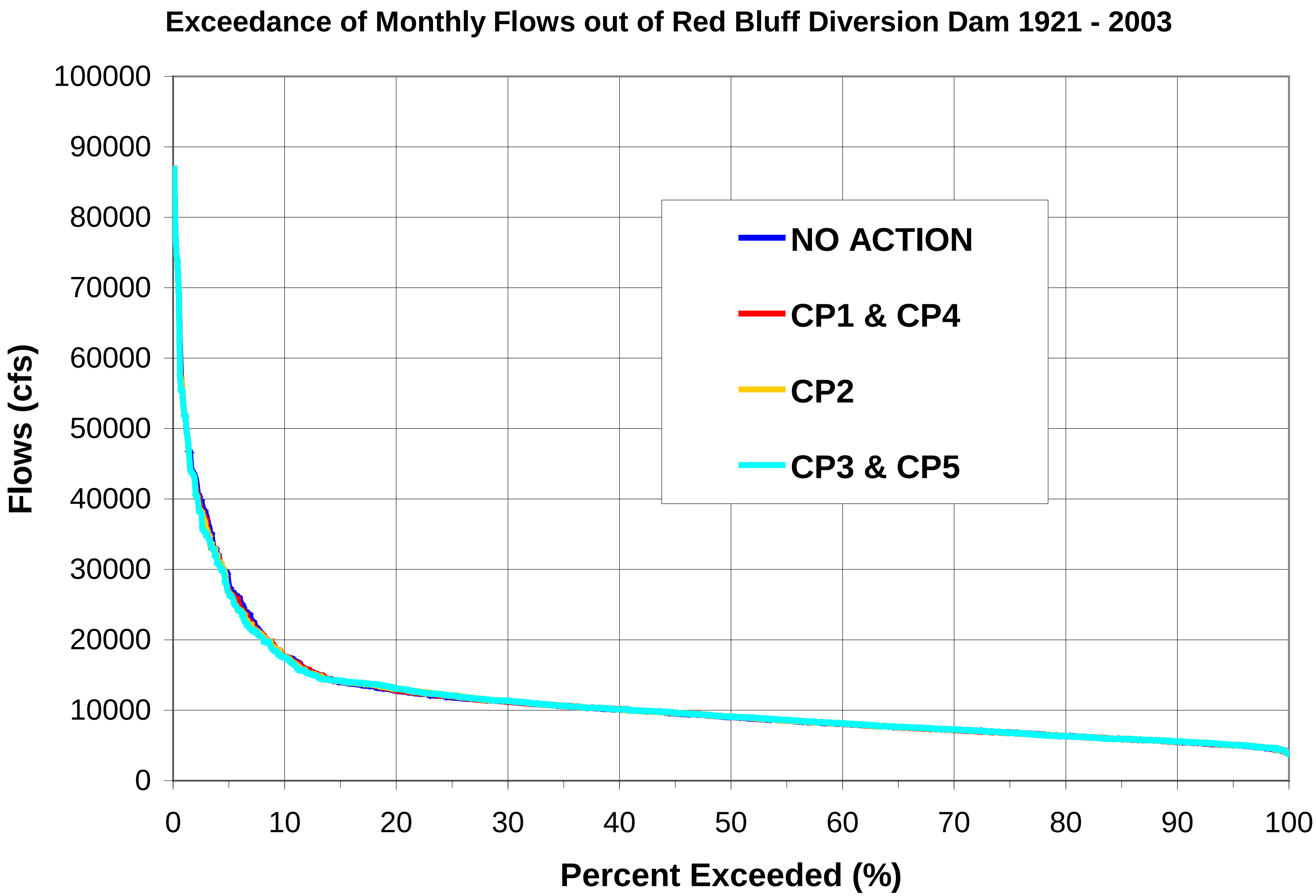

Figure 11. Frequency distribution of monthly flows out of Red Bluff Diversion Dam for the 1921 – 2003 CALSIM period of record.

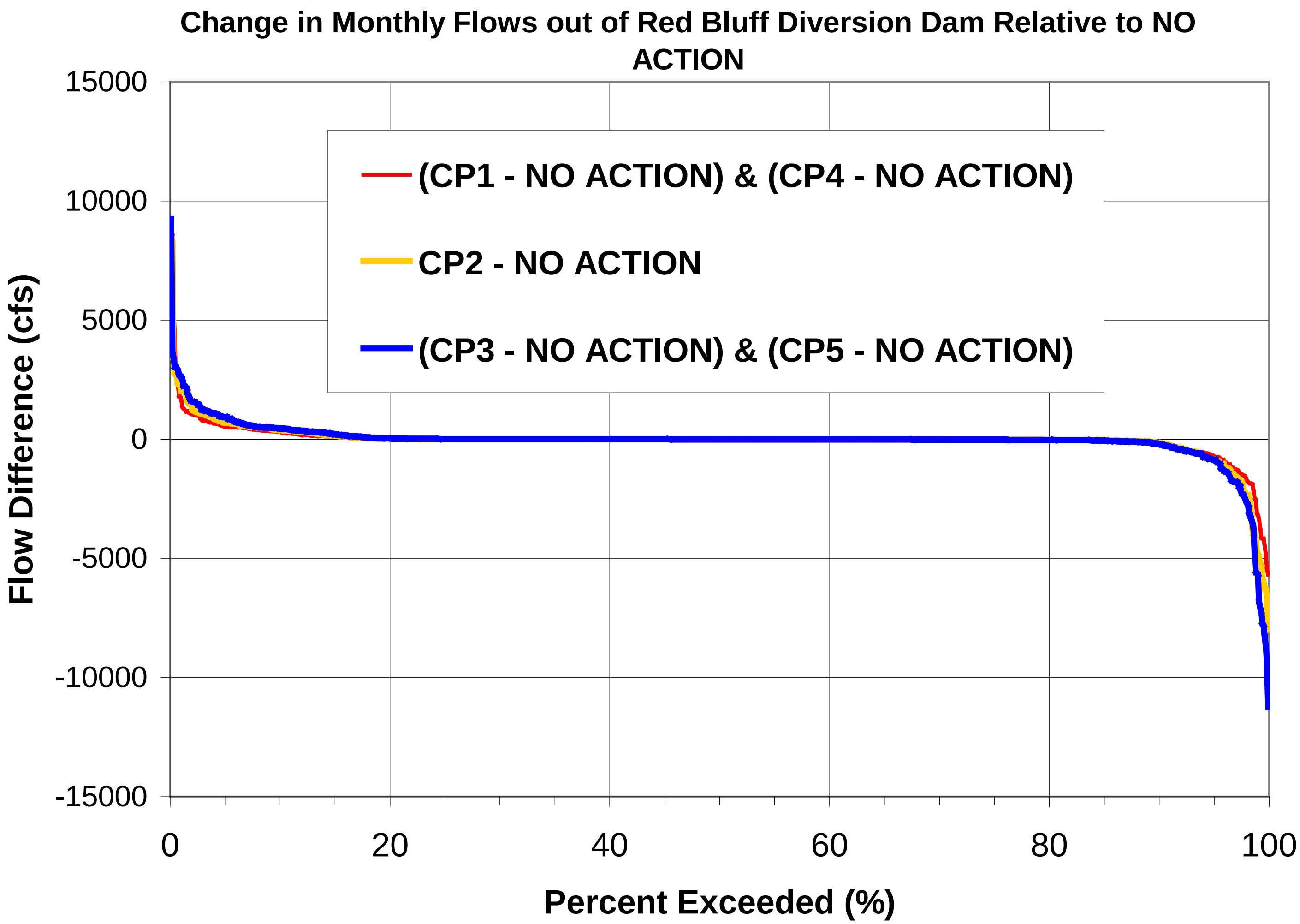

Figure 12. Frequency distribution of change in monthly flows out of Red Bluff Diversion Dam relative to NO ACTION.

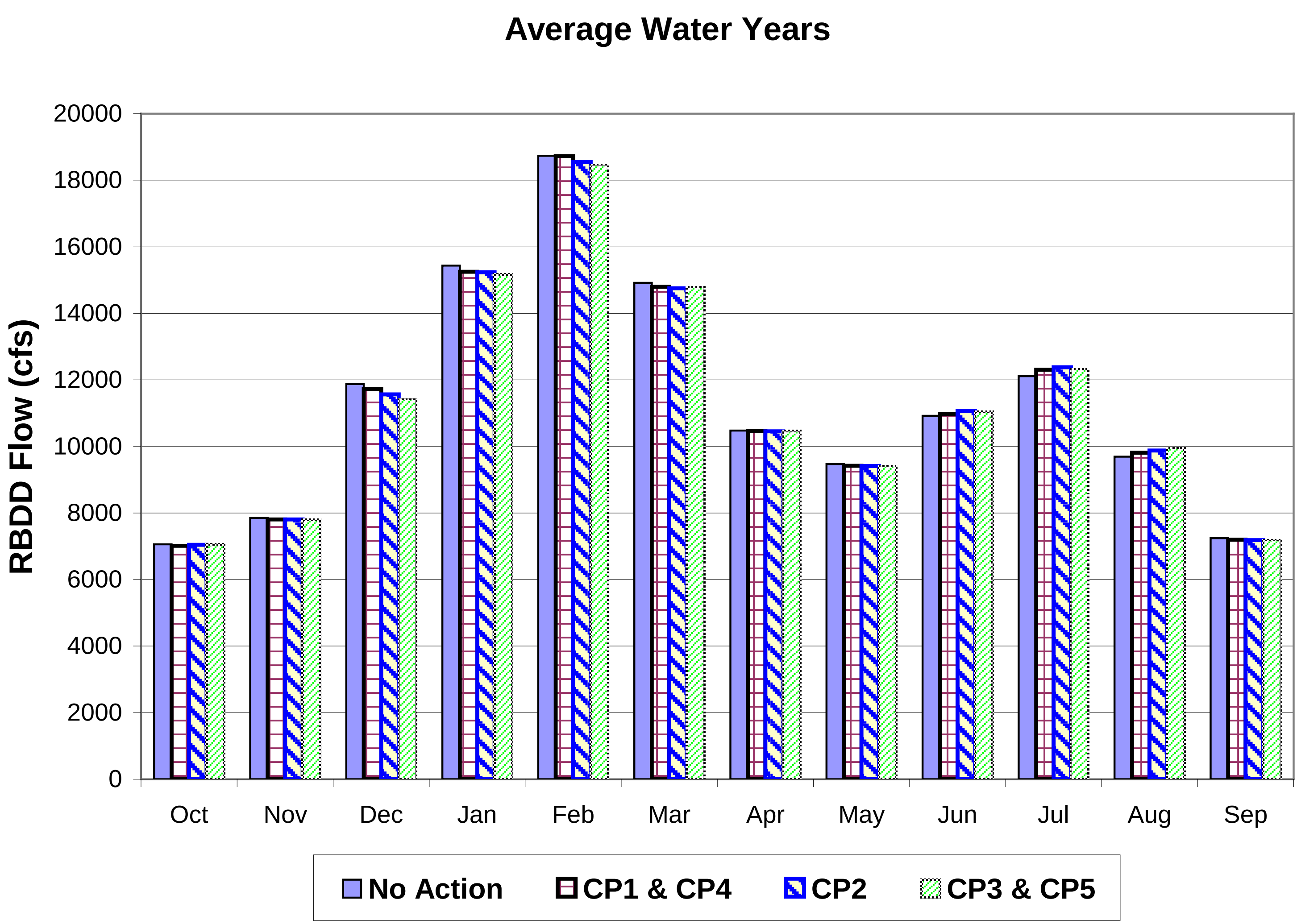

Figure 13A. Average monthly flows out of Red Bluff Diversion Dam (RBDD) during average water years for the period of record.

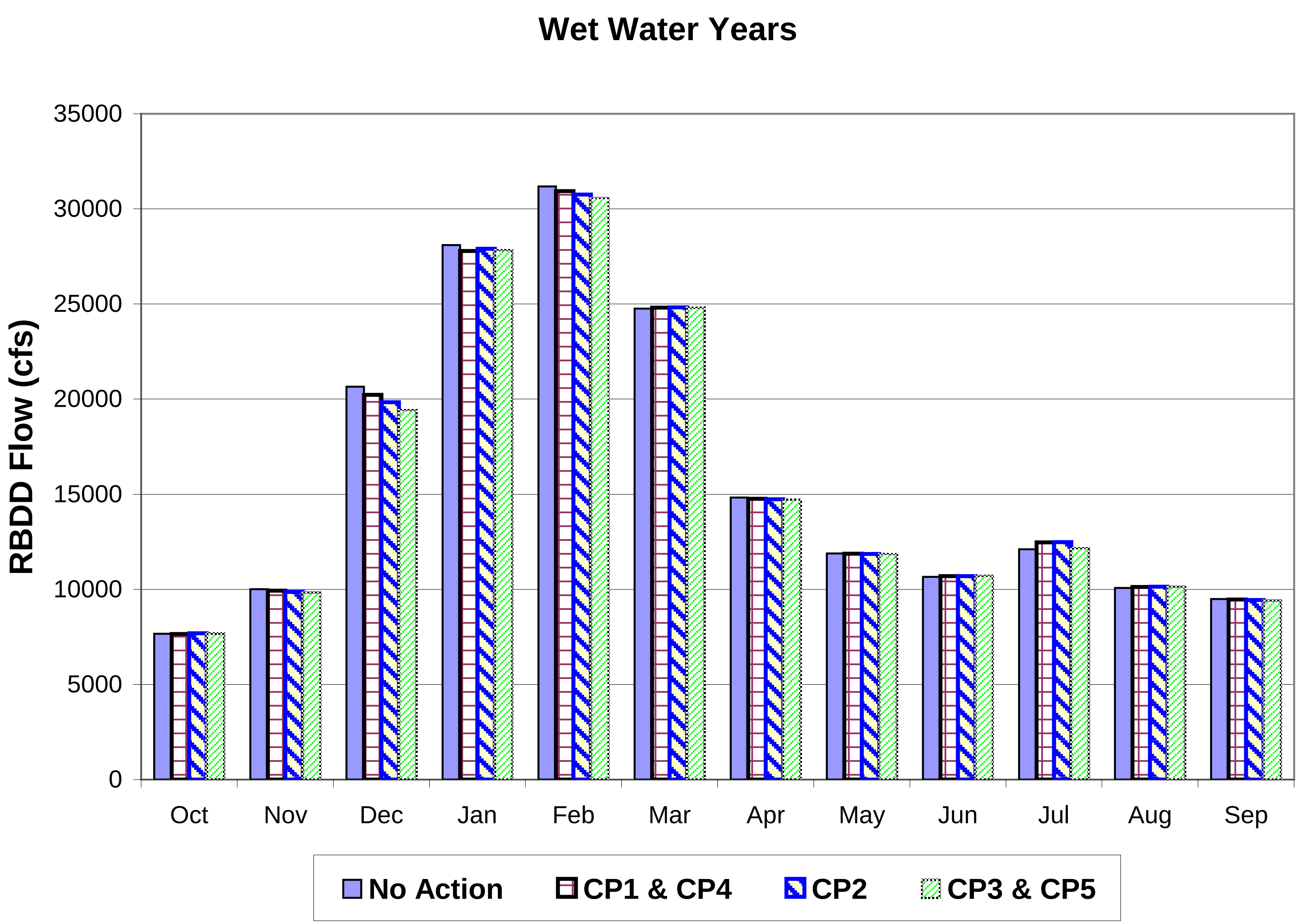

Figure 13B. Average monthly flows out of Red Bluff Diversion Dam (RBDD) during wet water years for the period of record.

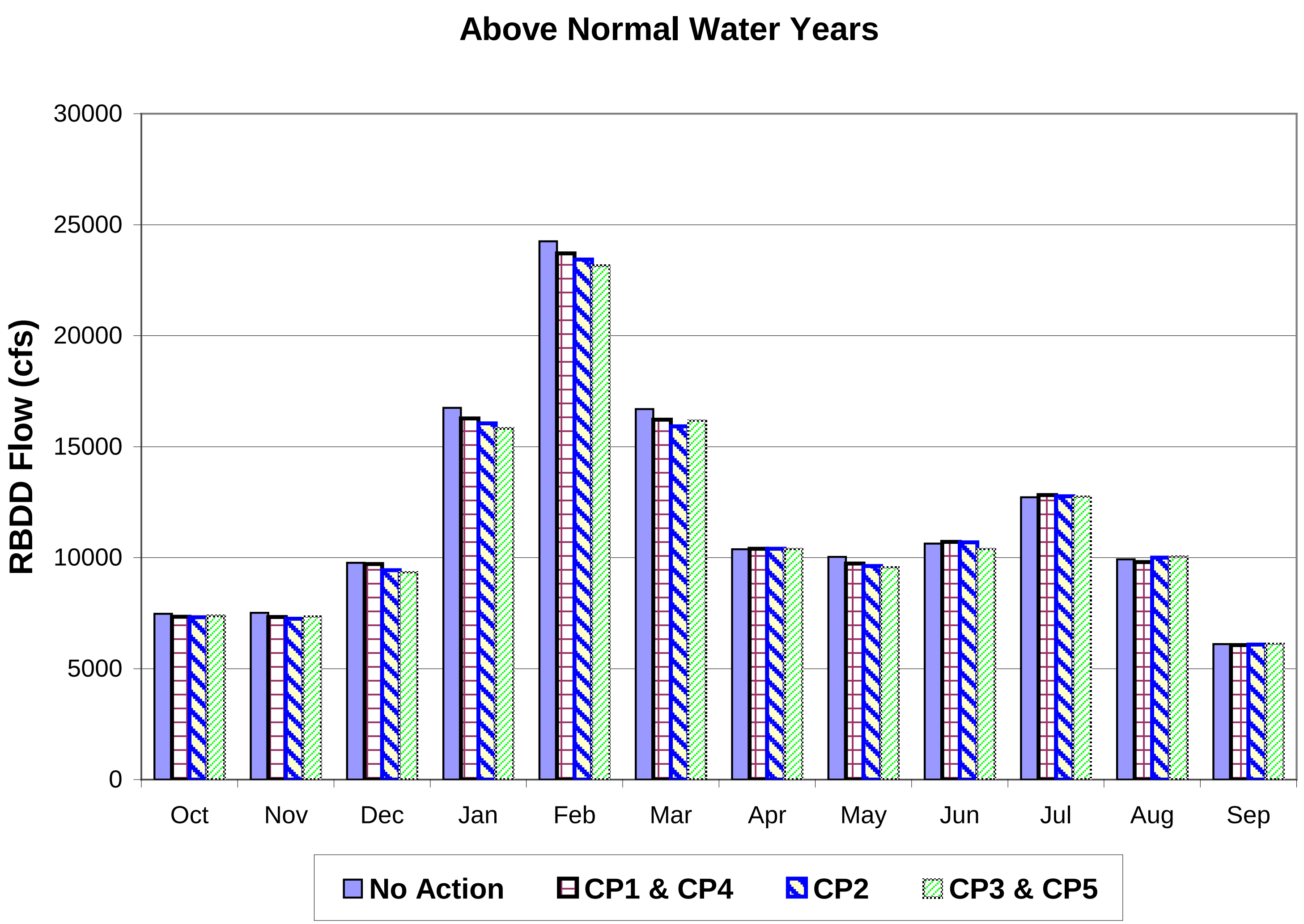

Figure 13C. Average monthly flows out of Red Bluff Diversion Dam (RBDD) during above normal water years.

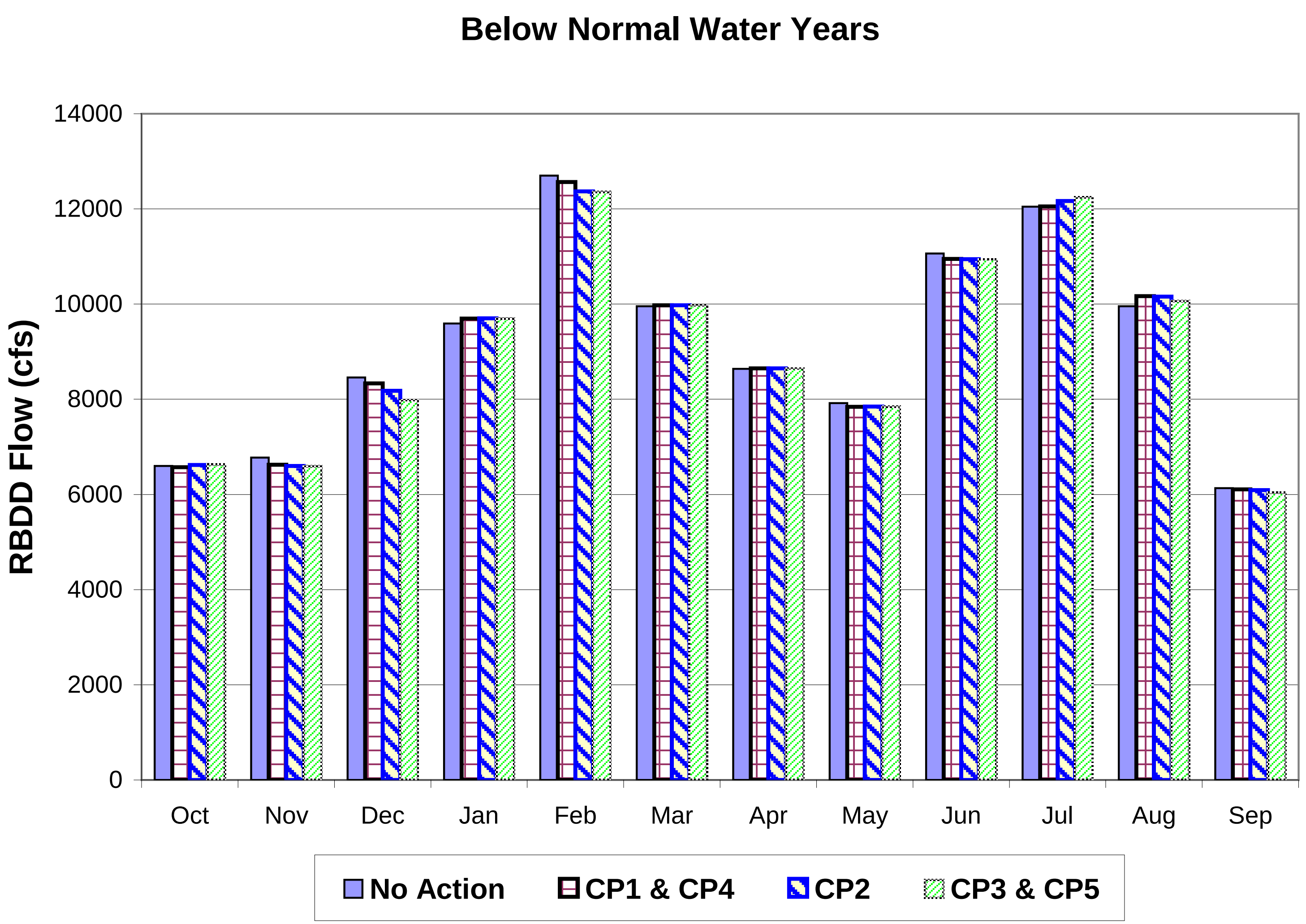

Figure 13D. Average monthly flows out of Red Bluff Diversion Dam (RBDD) during below normal water years.

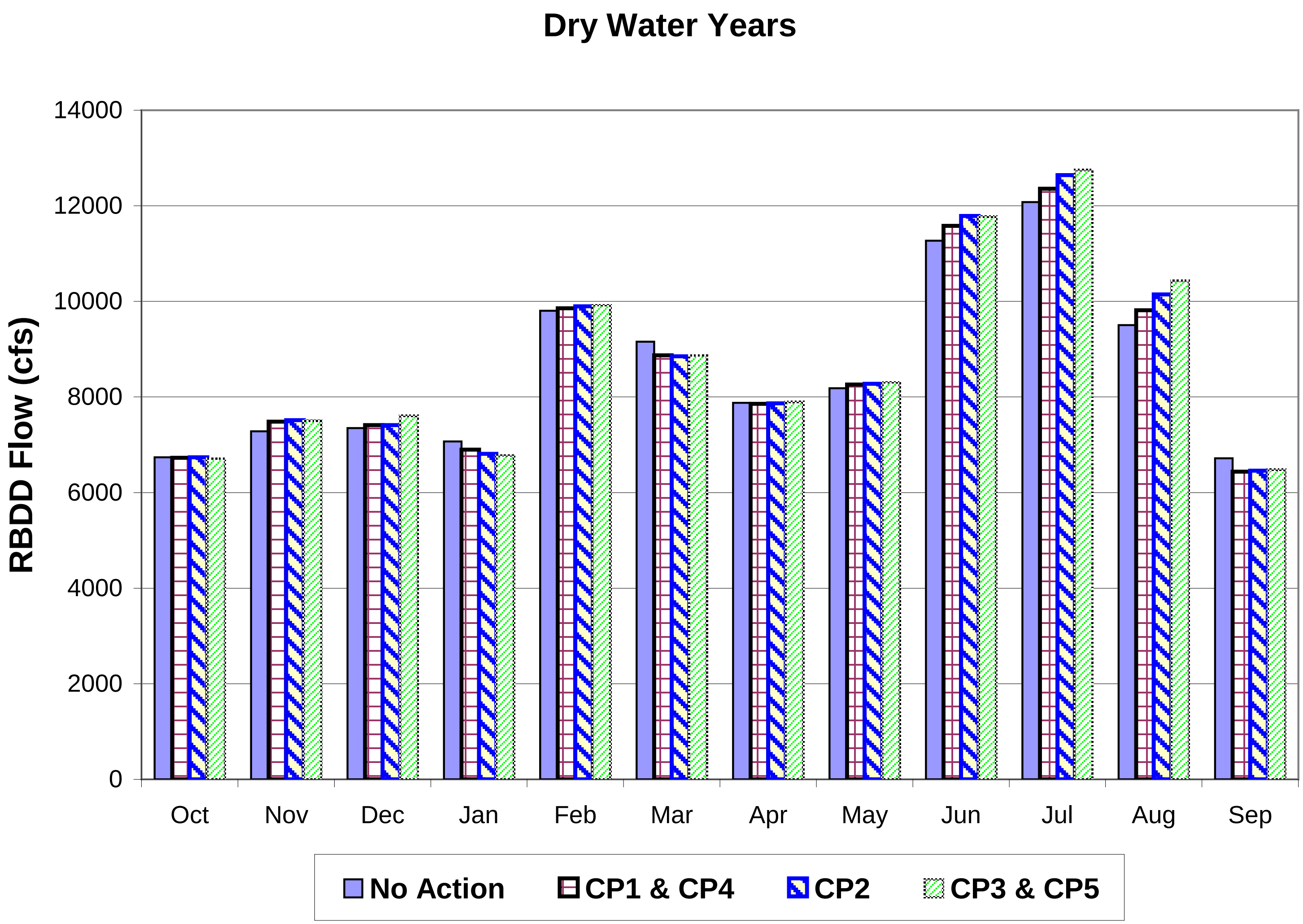

Figure 13E. Average monthly flows out of Red Bluff Diversion Dam (RBDD) during dry water years.

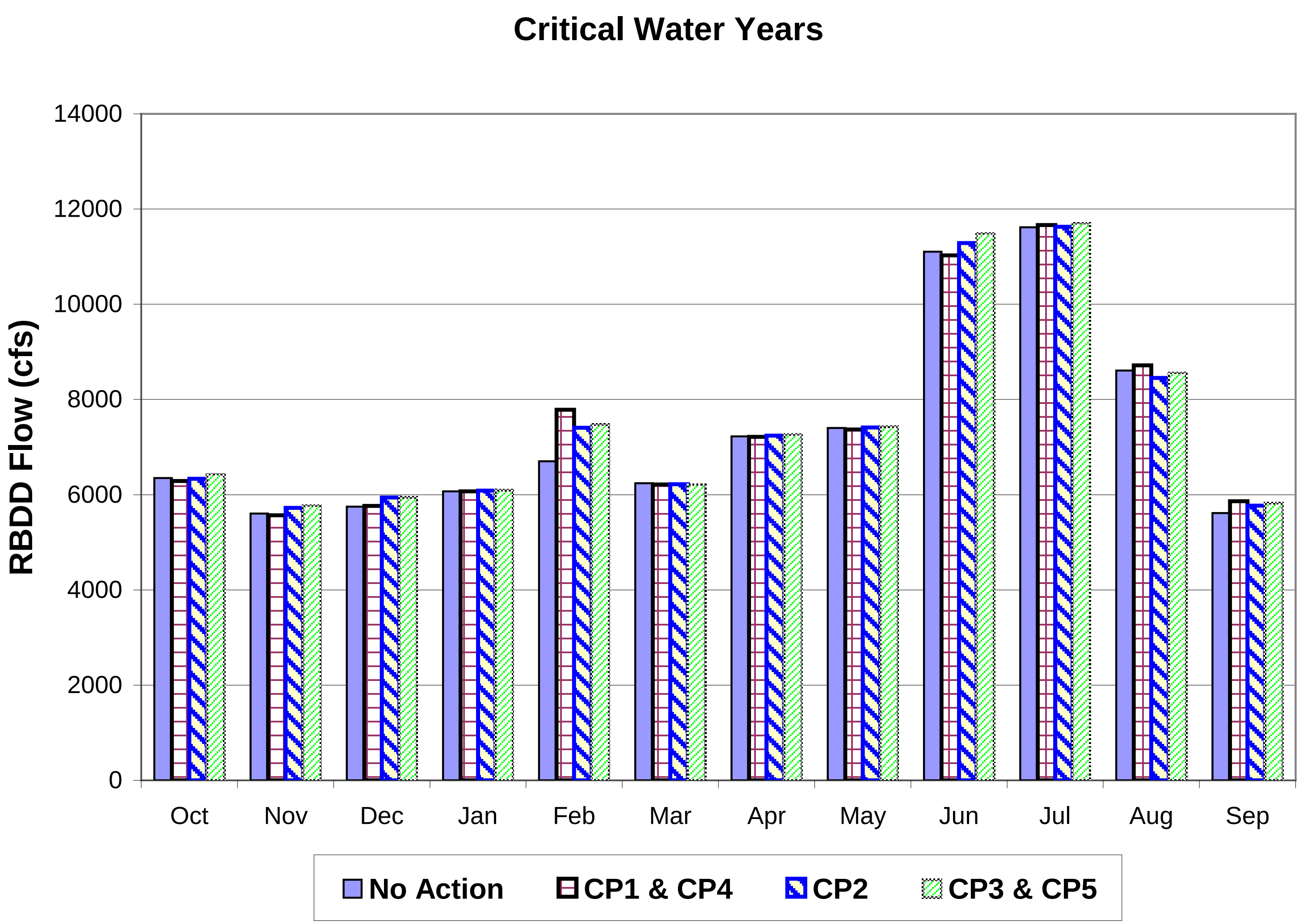

Figure 13F. Average monthly flows out of Red Bluff Diversion Dam (RBDD) during critical water years.

CP2 – 12.5-Foot Dam Raise

During average water years, there would be no significant change in the average monthly flows in the Sacramento River downstream from the RBDD in CP2 relative to No Action. During wet water years, average monthly flows out of the RBDD would decrease by 4 percent (822 cfs) in December. During above normal water years, average monthly flows out of the RBDD would decrease by 3 - 5 percent in December (329 cfs), January (712 cfs), February (826 cfs), and March (778 cfs). During below normal water years, average monthly flows out of the RBDD would decrease by 3 percent in December (279 cfs) and February (327 cfs). During dry water years, average monthly flows out of the RBDD would decrease by 3 – 4 percent in March and September (260 - 308 cfs) but would increase by 3 – 7 percent in November, January, June, July, and August (235 – 646 cfs) relative to No Action. The greatest increase in flows would occur during critical water years when the average monthly flows out of the RBDD would increase by 11 percent (707 cfs) in February to 7,409 cfs compared to 6,702 cfs in the No Action.

CP3 – 18.5-Foot Dam Raise

During average water years, there would be no significant change in the average monthly flows in the Sacramento River downstream from the RBDD in CP3 relative to No Action. During wet water years, average monthly flows out of the RBDD would decrease by 6 percent (1,238 cfs) in December and by 2 percent in February (617 cfs). During above normal water years, average monthly flows out of the RBDD would decrease by 3 - 6 percent in December (421 cfs), January (944 cfs), February (1,108 cfs), and March (526 cfs). During below normal water years, average monthly flows out of the RBDD would decrease by 6 percent in December (479 cfs) and by 3 percent in February (338 cfs). During dry water years, average monthly flows out of the RBDD would decrease by 3 – 4 percent in January, March, and September (240 - 295 cfs) but would increase by 3 – 10 percent in November, June, July, and August (224 – 927 cfs) relative to No Action. The greatest increase in flows would occur during critical water years when the average monthly flows out of the RBDD would increase by 12 percent (707 cfs) in February to 7,476 cfs compared to 6,702 cfs in the No Action; average monthly flows in June and July during critical water years would increase by 4 percent (211 – 384 cfs) in CP3 relative to No Action.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus

During average water years, there would be no significant change in the average monthly flows in the Sacramento River downstream from RBDD in CP4 relative to No Action. During wet water years, average monthly flows out of the RBDD would decrease by 2 percent (426 cfs) in December. During above normal water years, average monthly flows out of RBDD would decrease by 3 percent in January (489 cfs) and March (476 cfs) and by 2 percent in February (547 cfs). During below normal water years there would be no significant change in average monthly flows out of RBDD relative to No Action. During dry water years, average monthly flows out of RBDD would decrease by 3 – 4 percent in January, March, and September (278 – 287 cfs) but would increase by 2 – 3 percent in November, June, July, and August (170 – 306 cfs) relative to No Action. The greatest increase in flows would occur during critical water years when the average monthly flows out of RBDD would increase by 16 percent (1,080 cfs) in February to 7,782 cfs compared to 6,702 cfs in the No Action; average monthly flows in September of critical water years would increase by 4 percent (284 cfs) compared to No Action.

CP5 – 18.5-Foot Dam Raise, Combination Plan

The effects of CP5 on aquatic habitat in the Sacramento River between RBDD and the Delta are the same as in CP3 discussed above.

Terrestrial/Wetland Vegetation and Wildlife

Terrestrial, riparian, and wetland vegetation and wildlife along the Sacramento River would also be affected by changes in the timing, frequency, and duration of flows in the Sacramento River. Reduced winter flows would result in a loss of riparian cover and possible encroachment of upland vegetation and invasive species into riparian habitat. Changes in flows would affect the following aspects or riparian habitat: composition, age structure, quantity, growth, vigor, soil fertility/seed bed formation and quality, and regeneration/succession of riparian vegetation. Riparian vegetation would also be affected by increasing summer inundation. The SacEFT (ESSA Technologies Ltd. 2006) can evaluate the effects of changes in the flow regime on riparian habitat.

CP1 – 6.5 Foot Dam Raise

There is not enough data at this time to evaluate the effects of the SLWRI alternatives on riparian and upland vegetation and wildlife along the Sacramento River. The Service is currently waiting for an analysis of the SLWRI alternatives using the SacEFT.

CP2 – 12.5-Foot Dam Raise

There is not enough data at this time to evaluate the effects of the SLWRI alternatives on riparian and upland vegetation and wildlife along the Sacramento River. The Service is currently waiting for an analysis of the SLWRI alternatives using the SacEFT.

CP3 – 18.5-Foot Dam Raise

There is not enough data at this time to evaluate the effects of the SLWRI alternatives on riparian and upland vegetation and wildlife along the Sacramento River. The Service is currently waiting for an analysis of the SLWRI alternatives using the SacEFT.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus

There is not enough data at this time to evaluate the effects of the SLWRI alternatives on riparian and upland vegetation and wildlife along the Sacramento River. The Service is currently waiting for an analysis of the SLWRI alternatives using the SacEFT.

CP5 – 18.5-Foot Dam Raise, Combination Plan

There is not enough data at this time to evaluate the effects of the SLWRI alternatives on riparian and upland vegetation and wildlife along the Sacramento River. The Service is currently waiting for an analysis of the SLWRI alternatives using the SacEFT.

Special-Status Terrestrial Species

There is not enough data at this time to evaluate the effects of the SLWRI alternatives on special-status terrestrial species along the Sacramento River. However, changes in the timing, frequency, and duration of flood flows would affect the regeneration and maintenance of riparian vegetation important to sensitive migratory bird species such as the yellow-billed cuckoo and Swainson's hawk. The Service is currently waiting for an analysis of the SLWRI alternatives using the SacEFT. A more detailed analysis of the effects of the SLWRI on valley elderberry longhorn beetle and other federally listed species will be provided by the Service in Section 7 consultation under ESA.

Extended Study Area: Sacramento-San Joaquin Delta and the Yolo Bypass

The enlarging of Shasta Dam in the SLWRI alternatives was found to affect the timing, frequency, and duration of flood flows in the Sacramento River between Keswick Dam and RBDD (Figures 6 and 7A-F) and further downstream (Figures 12 and 13A-F). Changes in flood flows in the Sacramento River would affect hydroperiods in the Sutter and Yolo Bypasses. The Yolo Bypass in particular provides important rearing habitat for juvenile salmonids and special-status Delta fish species such as delta smelt, Sacramento splittail, and longfin smelt. The Yolo Bypass is designated as critical habitat for Central Valley spring-run Chinook salmon (70 FR 170). There is no information available at this time to evaluate the effects of the SLWRI on hydroperiods and the frequency of flooding of the Yolo and Sutter Bypasses. CALSIM modeling simulates the flooding of the Yolo and Sutter Bypasses using a monthly time step which misses the important flood events that operate on daily and weekly time scales.

The enlarging of Shasta Dam in the SLWRI alternatives is also likely to affect sensitive aquatic species in the Delta through changes in the timing, frequency, and duration of flows in the Sacramento River and changes in Delta exports. A decrease in Sacramento River flood flows would reduce Bay-Delta flushing flows, affect Delta water quality (*e.g.*, X2 locations, contaminant dilution), and affect Delta outflows and inflow/export ratios. All of these factors may further contribute to pelagic organism decline in the Delta.

Increased water supply reliability in the SLWRI alternatives is also likely to increase Delta exports (pumping at Tracy and Banks) during dry and critical water years. All of these factors will affect sensitive Delta species such as delta smelt, Sacramento splittail, and longfin smelt as well as juvenile salmonids. There is not enough information at this time to evaluate the effects of the SLWRI alternative on Delta outflows and the location of X2. However, Figures 14A and 14B illustrate the effects of the SLWRI alternatives on Delta exports at the Tracy and Banks pumping facilities, respectively. The results in Figures 14A-B are discussed for each of the SLWRI alternatives below.

CP1 – 6.5 Foot Dam Raise

During February in critical water years, CP1 would result in an increase Delta exports pumping from 2,200 to 2,600 cfs at the Tracy SWP facility and from about 3,300 to 3,900 cfs at the Banks CVP facility compared to the No Action Alternative (Figures 14A and 14B). Increasing Delta exports, especially during critically dry years, would result in an increase in the entrainment of fish at the Tracy and Banks pumping facilities. In particular, increasing Delta exports during delta smelt spawning in February could increase entrainment of this federally-listed species especially during critically dry years when the location of X2 is in the eastern Delta.

CP2 – 12.5-Foot Dam Raise

During February in critical water years, CP2 would result in an increase Delta exports pumping from 2,200 to 2,900 cfs at the Tracy SWP facility and from about 3,300 to 3,600 cfs at the Banks CVP facility compared to the No Action Alternative (Figures 14A and 14B). Increasing Delta exports, especially during critically dry years, would result in an increase in the entrainment of fish at the Tracy and Banks pumping facilities. In particular, increasing Delta exports during delta smelt spawning in February could increase entrainment of this federally-listed species especially during critically dry years when the location of X2 is in the eastern Delta.

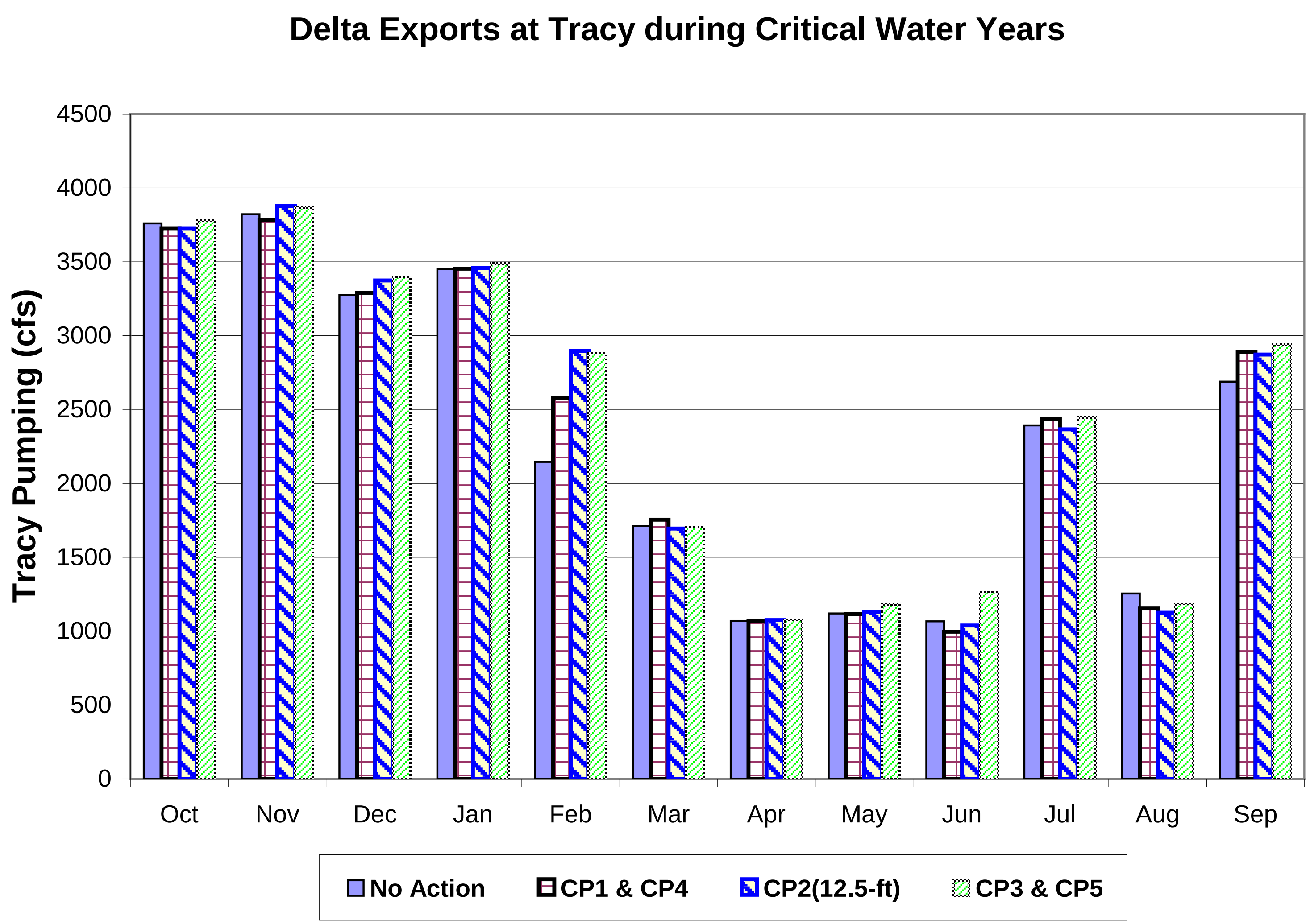

Figure 14A. Average monthly pumping by the Tracy facility during critical water years during the 1921 – 2003 period of record.

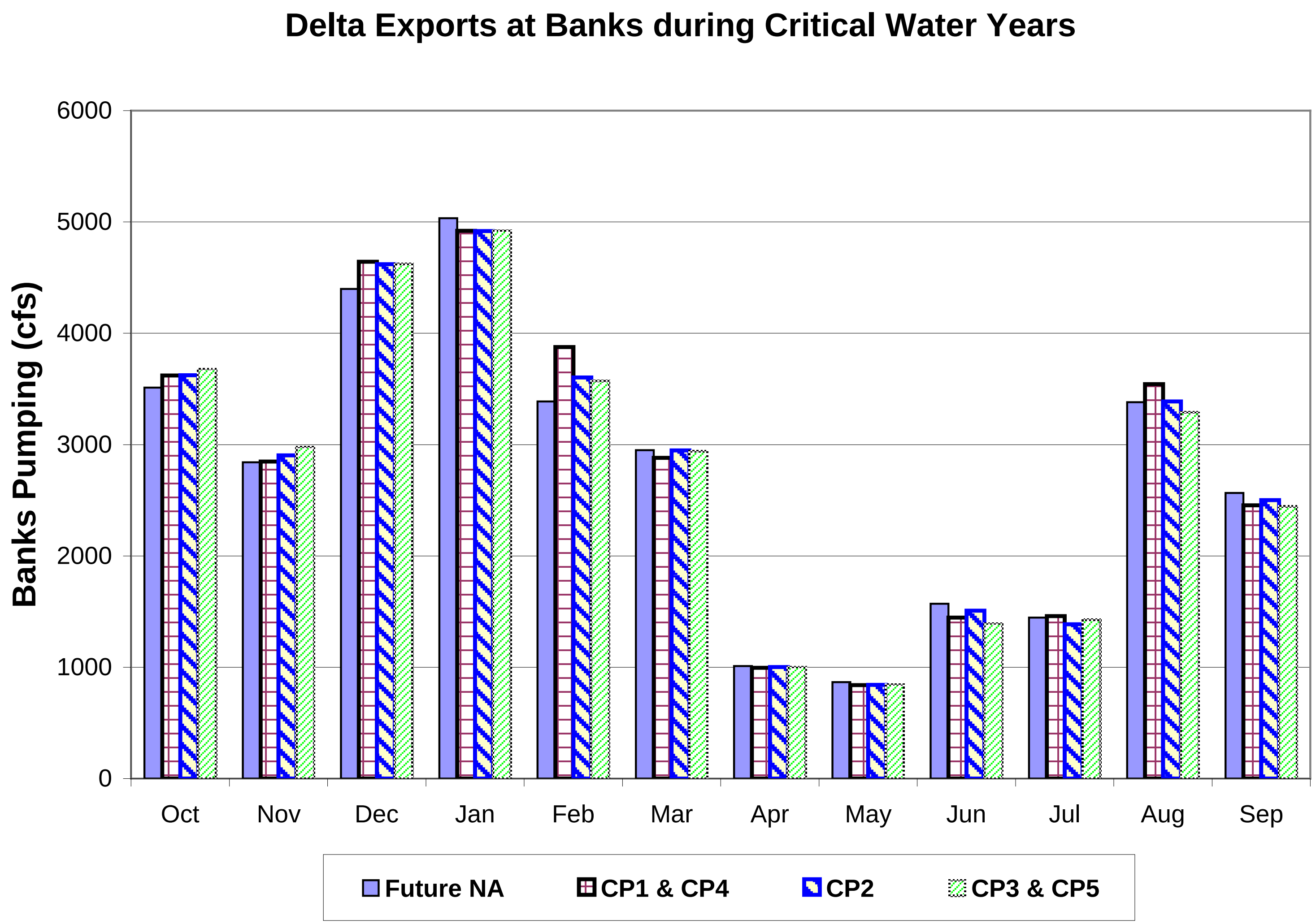

Figure 14B. Average monthly pumping by the Banks facility during critical water years during the 1921 – 2003 period of record

CP3 – 18.5-Foot Dam Raise

During February in critical water years, CP3 would result in an increase Delta exports pumping from 2,200 to 2,900 cfs at the Tracy SWP facility and from about 3,300 to 3,500 cfs at the Banks CVP facility compared to the No Action Alternative (Figures 14A and 14B). Increasing Delta exports, especially during critically dry years, would result in an increase in the entrainment of fish at the Tracy and Banks pumping facilities. In particular, increasing Delta exports during delta smelt spawning in February could increase entrainment of this federally-listed species especially during critically dry years when the location of X2 is in the eastern Delta.

CP4 – 18.5-Foot Dam Raise, Anadromous Fish Focus

Like CP1, during February in critical water years, CP4 would result in an increase Delta exports pumping from 2,200 to 2,600 cfs at the Tracy SWP facility and from about 3,300 to 3,900 cfs at the Banks CVP facility compared to the No Action Alternative (Figures 14A and 14B). Increasing Delta exports, especially during critically dry years, would result in an increase in the entrainment of fish at the Tracy and Banks pumping facilities. In particular, increasing Delta exports during delta smelt spawning in February could increase entrainment of this federally-listed species especially during critically dry years when the location of X2 is in the eastern Delta.

CP5 – 18.5-Foot Dam Raise, Combination Plan

Like CP3, during February in critical water years, CP5 would result in an increase Delta exports pumping from 2,200 to 2,900 cfs at the Tracy SWP facility and from about 3,300 to 3,500 cfs at the Banks CVP facility compared to the No Action Alternative (Figures 14A and 14B). Increasing Delta exports, especially during critically dry years, would result in an increase in the entrainment of fish at the Tracy and Banks pumping facilities. In particular, increasing Delta exports during delta smelt spawning in February could increase entrainment of this federally-listed species especially during critically dry years when the location of X2 is in the eastern Delta.

Special-status Species

A more detailed analysis of the effects of the SLWRI on delta smelt, winter-run Chinook salmon, spring-run Chinook salmon, steelhead, green sturgeon and other federally listed species will be provided by the Service and NOAA Fisheries in Section 7 consultation under ESA.

Extended Study Area: Downstream from other CVP and SWP Dams

Each of the SLWRI alternatives would likely result in changes in the operation of the CVP and SWP dams throughout the Central Valley. These changes in the operation of CVP and SWP dams would affect wildlife within the reservoirs as well as downstream from the dams. Rivers likely to be affected include the American River, Feather River, San Joaquin River, and other rivers within the CVP-SWP area. At this time, it is not known what the effect each of the SLWRI alternatives would have on the operation of other CVP and SWP dams. However, the results from CALSIM simulations of Oroville and Folsom Reservoirs are discussed below.

Feather River

Figure 15 below illustrates the difference in water storage in Oroville Reservoir during critical water years between the No Action and the SLWRI alternatives. During critical water years, the SLWRI alternatives had less water storage in Oroville Reservoir relative to the No Action alternative in every month of the year. In CP1 and CP4, monthly water storage in Oroville Reservoir decreased by 35,000 – 56,000 af during critical water years relative to No Action. In CP2, monthly water storage in Oroville Reservoir decreased by 48,000 – 69,000 af during critical water years relative to No Action. In CP3 and CP5, monthly water storage in Oroville Reservoir decreased by 59,000 – 94,000 af during critical water years relative to No Action. The decrease in water storage at Oroville Reservoir in the SLWRI alternatives relative to No Action would likely have adverse affects on spring-run and fall-run Chinook salmon and steelhead trout in the Feather River. The decrease in storage at Oroville Reservoir during critical water years would likely inhibit the ability to maintain adequate temperature and flow conditions for anadromous fish spawning and rearing there. Figure 16 shows that during critical water years the average monthly flows in the Feather River downstream of Thermalito increase in all SLWRI alternatives by 118 – 127 cfs in October and by 266 – 340 cfs in December; however, in February, June, and September flows decreased by 61 – 241 cfs.

American River

Figure 17 below illustrates the difference in water storage in Folsom Reservoir during critical water years between the No Action and the SLWRI alternatives. During critical water years, the SLWRI alternatives had more water storage in Folsom Reservoir relative to the No Action alternative in every month of the year. In CP1 and CP4, monthly water storage in Folsom Reservoir increased by 3,600 – 8,400 af during critical water years relative to No Action. In CP2, monthly water storage in Folsom Reservoir increased by 3,500 – 10,700 af during critical water years relative to No Action. In CP3 and CP5, monthly water storage in Folsom Reservoir increased by 8,600 – 13,800 af during critical water years relative to No Action. The increase in water storage at Folsom Reservoir in the SLWRI alternatives relative to No Action would likely benefit fall-run Chinook salmon and steelhead trout in the American River by providing adequate temperature and flows for spawning and rearing there. Figure 18 shows that during critical water years, flows in the American River downstream of Nimbus Dam would decrease by 71 cfs in June in CP2 and decrease by 56- 88 cfs in July in all the SLWRI alternatives; during the rest of the months changes in flows relative to No Action were less than 50 cfs.

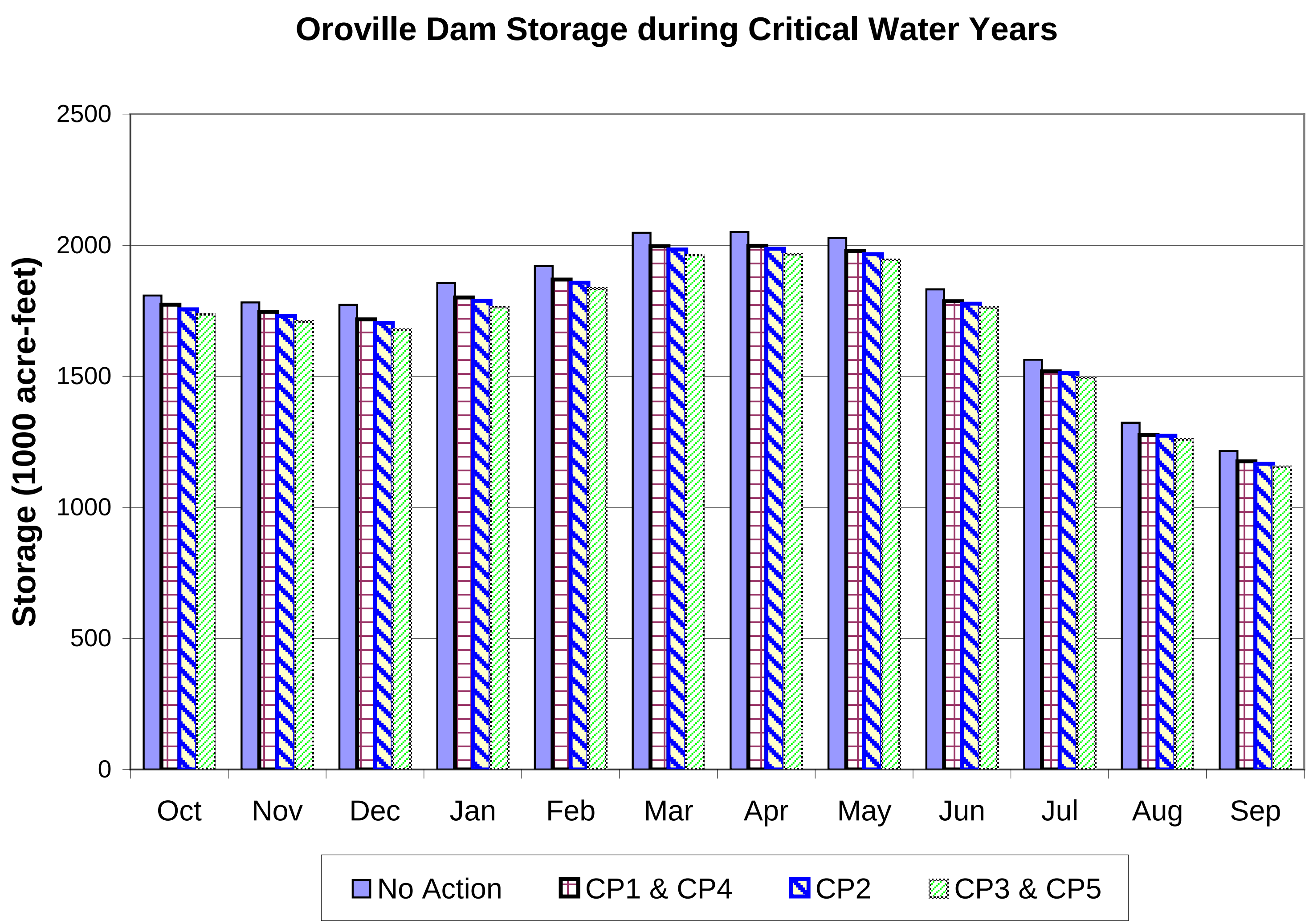

Figure 15. Oroville Dam storage during critical water years for the period of record.

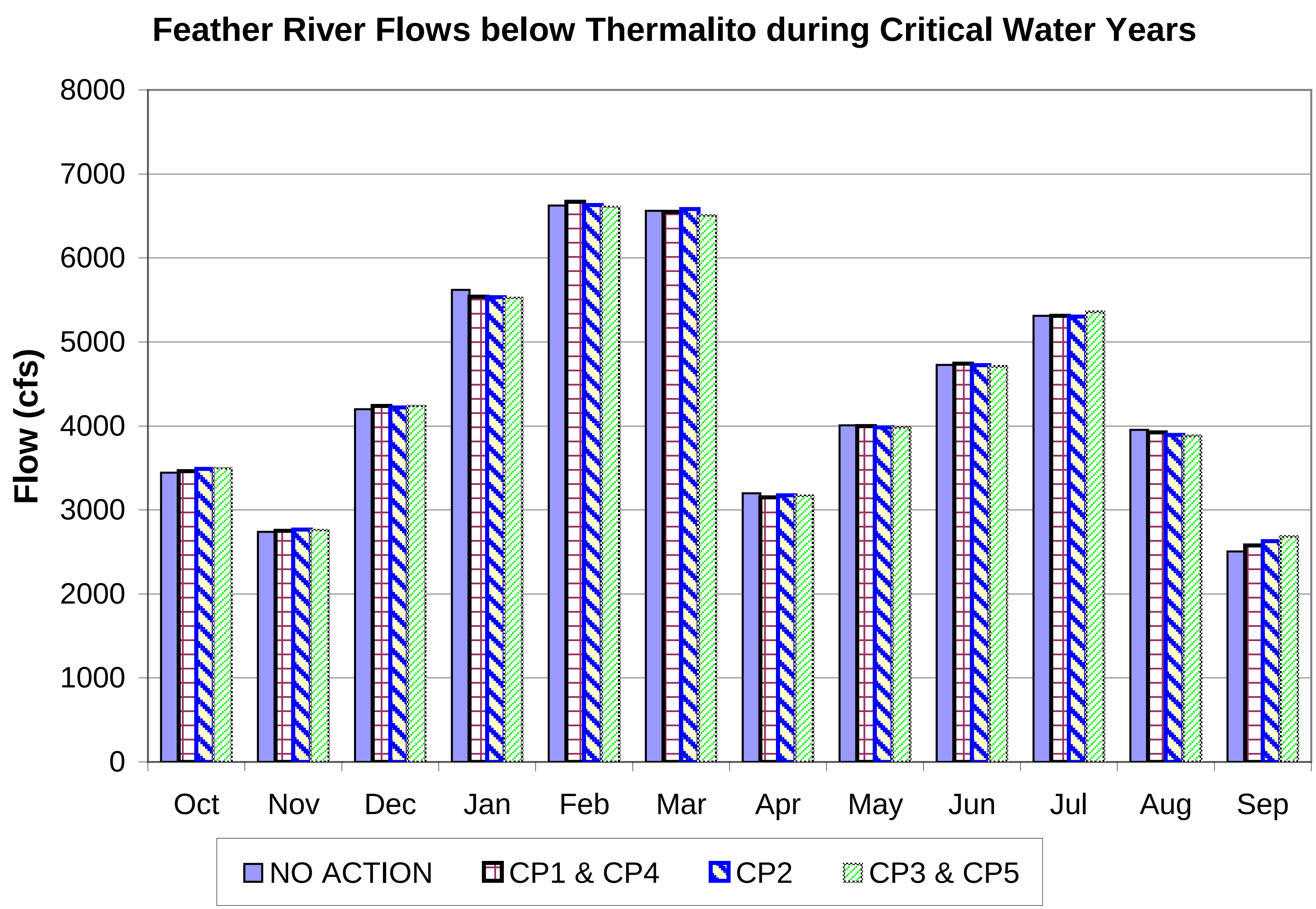

Figure 16. Average monthly flows in the Feather River below Thermalito during critical water years.

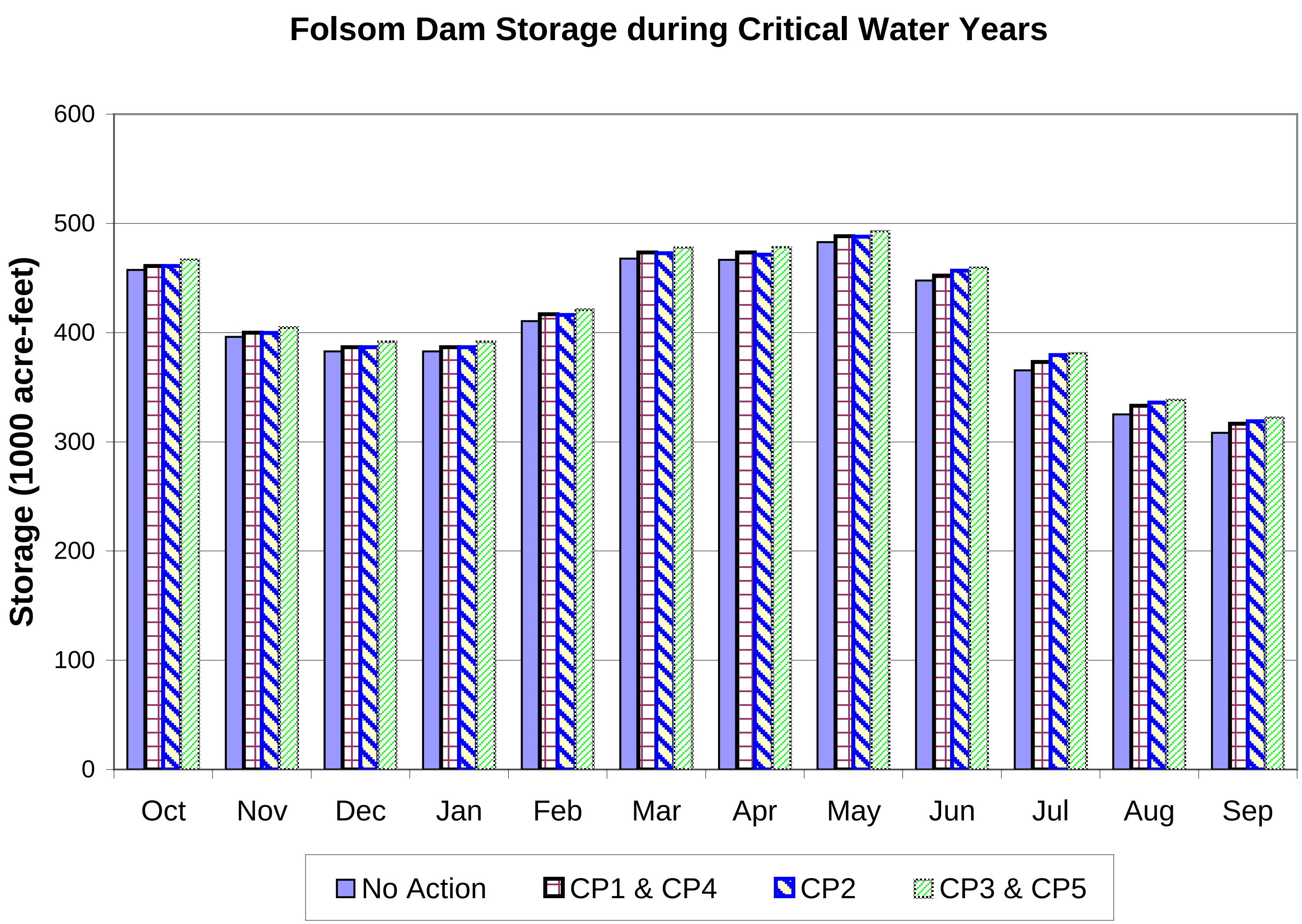

Figure 17. Folsom Dam storage during critical water years for the period of record.

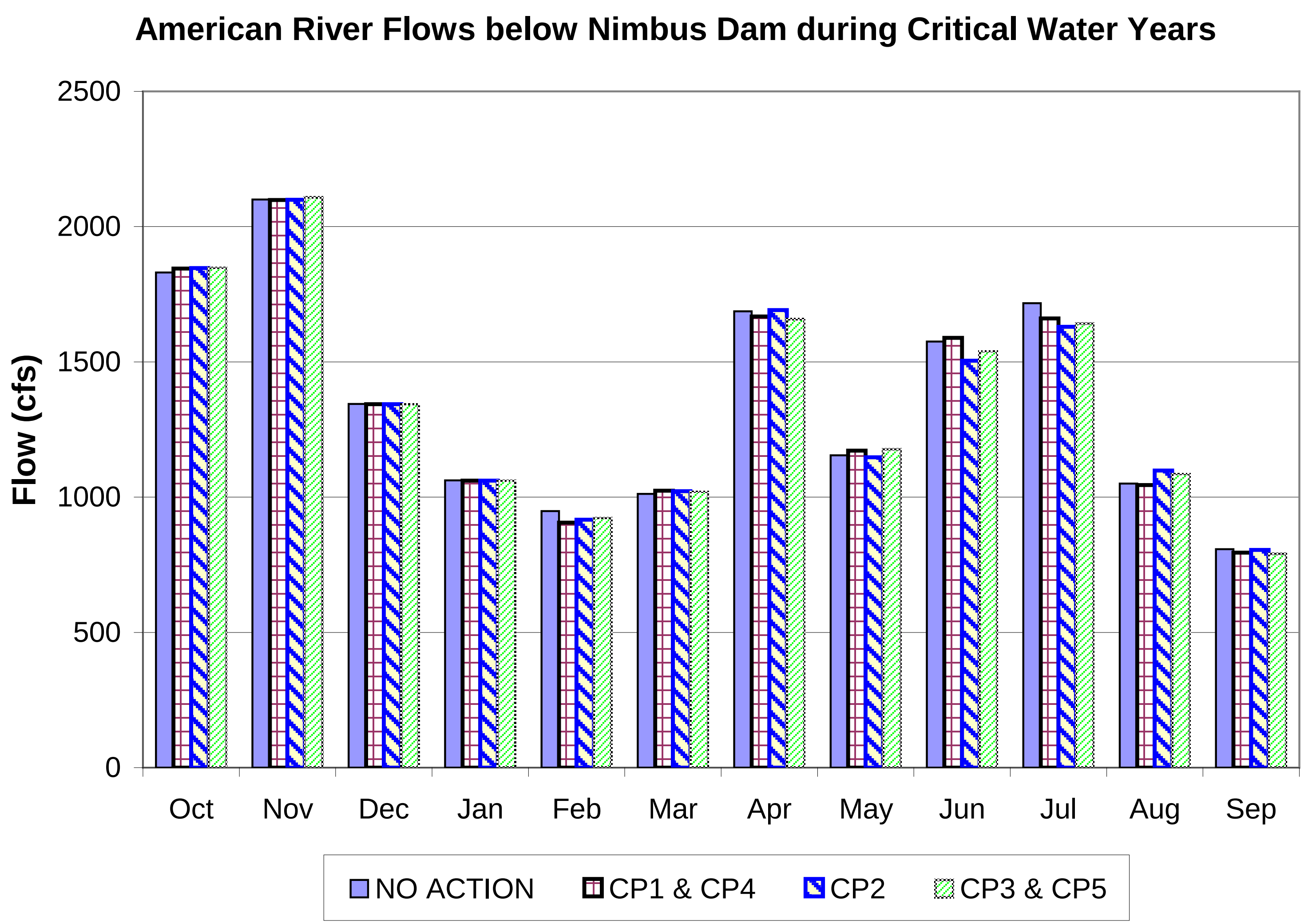

Figure 18. Flows in the American River below Nimbus Dam during critical water years.

Also during dry water years, the SLWRI alternatives had more water storage in Folsom Reservoir relative to the No Action alternative in every month of the year. In CP1 and CP4, monthly water storage in Folsom Reservoir increased by 1,700 – 14,000 af during dry years relative to No Action. In CP2, monthly water storage in Folsom Reservoir increased by 4,700 – 14,700 af during dry water years relative to No Action. In CP3 and CP5, monthly water storage in Folsom Reservoir increased by 8,000 – 22,600 af during dry water years relative to No Action.

Special-status Species

A more detailed analysis of the effects of the SLWRI on spring-run Chinook salmon, steelhead, green sturgeon and other federally listed species will be provided by NOAA Fisheries in Section 7 consultation under ESA.

<u>Extended Study Area: CVP and SWP Water Service Areas</u>

The CVP and SWP water service areas include agricultural and M&I water users throughout the Central Valley and Southern California. Increasing water reliability with the SLWRI would likely have growth-inducing effects resulting in changes in land use patterns within CVP and SWP water service areas, particularly within the San Joaquin Valley. The increased water supply reliability would likely accelerate the conversion of natural lands in the San Joaquin Valley to agricultural and urban development. Also, increased water supply reliability would likely increase the conversion of agricultural lands to urban sprawl within the Central Valley and Southern California. In addition, increased water supply reliability would likely change the types of crops that are grown in the Central Valley. All of these growth-inducing effects and changes in land use would adversely affect sensitive wildlife species within the Central Valley and Southern California. There is not enough information at this time to adequately analyze the effects of the SLWRI alternatives on habitat for common and special-status wildlife species in the CVP and SWP water service areas. The effects of the SLWRI on federally-listed species within the CVP and SWP water service areas would be evaluated in Section 7 consultation under the ESA.

SERVICE MITIGATION POLICY

The recommendations provided herein for the protection of fish and wildlife resources are in accordance with the Service's Mitigation Policy as published in the Federal Register (46:15; January 23, 1981).

The Mitigation Policy provides Service personnel with guidance in making recommendations to protect or conserve fish and wildlife resources. The policy helps ensure consistent and effective Service recommendations, while allowing agencies and developers to anticipate Service recommendations and plan early for mitigation needs. The intent of the policy is to ensure protection and conservation of the most important and valuable fish and wildlife resources, while allowing reasonable and balanced use of the Nation's natural resources.

Under the Mitigation Policy, resources are assigned to one of four distinct Resource Categories, each having a mitigation planning goal which is consistent with the fish and wildlife values involved. The Resource Categories cover a range of habitat values from those considered to be unique and irreplaceable to those believed to be much more common and of relatively lesser value to fish and wildlife. The Mitigation Policy does not apply to threatened and endangered species, Service recommendations for completed Federal projects or projects permitted or licensed prior to enactment of Service authorities, or Service recommendations related to the enhancement of fish and wildlife resources, however.

In applying the Mitigation Policy during an impact assessment, the Service first identifies each specific habitat or cover-type that may be impacted by the project. Evaluation species which utilize each habitat or cover-type are then selected for Resource Category analysis. Selection of evaluation species can be based on several rationale, as follows: (1) species known to be sensitive to specific land- and water-use actions; (2) species that play a key role in nutrient cycling or energy flow; (3) species that utilize a common environmental resource; or (4) species that are associated with Important Resource Problems, such as anadromous fish and migratory birds, as designated by the Director or Regional Directors of the Service. (Note: Evaluation species used for Resource Category determinations may or may not be the same evaluation species used in a HEP application, if one is conducted.) Based on the relative importance of each specific habitat to its selected evaluation species, and the habitat's relative abundance, the appropriate Resource Category and associated mitigation planning goal are determined.

Mitigation planning goals range from "no loss of existing habitat value" (*i.e.*, Resource Category 1) to "minimize loss of habitat value" (*i.e.*, Resource Category 4). The planning goal of Resource Category 2 is "no net loss of in-kind habitat value"; to achieve this goal, any unavoidable losses would need to be replaced in-kind. "In-kind replacement" means providing or managing substitute resources to replace the habitat value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate those lost. In addition to mitigation goals based on its Mitigation Policy, the Service supports a goal of no net loss of wetland acreage, while seeking a net overall gain in the quality and quantity of wetlands through restoration, development and enhancement.

Eleven fish and/or wildlife habitats were identified in the SLWRI Project area in the vicinity of Shasta Lake which had potential for impacts from the Project. These are annual grassland, blue oak woodland, blue oak – gray pine, closed-cone pine – cypress, mixed chaparral, montane hardwood - conifer, montane hardwood, montane riparian, ponderosa pine, Sierran mixed conifer, riverine, and lacustrine. Another 11 fish and/or wildlife habitats were identified along the Sacramento River (and lower reaches of tributaries) from Keswick Dam to the Sacramento – San Joaquin Delta which had potential for impacts from the Project. These are Shaded Riverine Aquatic (SRA) Cover, riverine, oak woodland, blackberry scrub, Great Valley willow scrub, Great Valley cottonwood riparian forest, Great Valley mixed riparian forest, Great Valley valley oak riparian forest, freshwater seep, seasonal wetland, and estuarine. The resource categories, evaluation species, and mitigation planning goal for the cover-types impacts by the SLWRI are summarized below for habitats in the vicinity of Shasta Lake (Table 10) and along the Sacramento River from Keswick Dam to the Sacramento – San Joaquin Delta (Table 11).

The evaluation species selected for the annual grassland cover-type that would be impacted in the vicinity of Shasta Lake are red-tailed hawk and greater western-mastiff bat. The red-tailed hawk was selected because of the Service's responsibility for their protection and management under the Migratory Bird Treaty Act, and their overall high non-consumptive values to humans. The greater western-mastiff bat was selected because of its association with annual grassland habitat and its status as a CALFED MSCS species. Several bat roosting caves would be inundated by the SLWRI. Annual grassland areas potentially impacted by the SLWRI vary in their relative values to the evaluation species, depending on the degree human disturbances, plant species composition, and juxtaposition to other foraging and nesting areas. Therefore, the Service designates the annual grassland cover-type within the Project area as Resource Category 3. Our associated mitigation planning goal for these areas is "no net loss of habitat value while minimizing loss of in-kind habitat value."

The evaluation species selected for the blue oak woodland and the blue oak – gray pine cover-types that would be impacted in the vicinity of Shasta Lake are acorn woodpecker and turkey. Acorn woodpeckers utilize oak woodlands for nearly all their life requisites; 50-60 percent of the acorn woodpecker's annual diet consists of acorns. Acorn woodpeckers can also represent impacts to other canopy-dwelling species. Turkeys forage and breed in oak woodlands and are abundant in the project area. The turkey represents species which utilize the ground component of the habitat and it has important consumptive and non-consumptive human uses (*i.e.*, hunting and bird watching). Because blue oak is a slow growing, long lived species and is not regenerating in many parts of its range (Schoenherr 1992), and acorns are an important food for many wildlife species, the Service has designated these habitats as Resource Category 2. Our associated mitigation planning goal for these areas is "no net loss of in-kind habitat value."

Table 10. Resource Categories, Evaluation Species, and Mitigation Planning Goal for the Habitats in the Vicinity of Shasta Lake Impacted by the Shasta Lake Water Resources Investigation Project.

Cover-type	Evaluation Species	Resource Category	Mitigation Goal
Annual grassland	Red-tailed hawk Greater western-mastiff bat	3	No net loss of habitat value while minimizing loss of in-kind habitat values.
Blue oak woodland	Acorn woodpecker Turkey	2	No net loss of in-kind habitat value.
Blue oak – gray pine	Acorn woodpecker Turkey	2	No net loss of in-kind habitat value.
Closed-cone pine – cypress	Great horned owl Red-tailed hawk	3	No net loss of habitat value while minimizing loss of in-kind habitat values.
Mixed chaparral	Wrentit Ringtail	3	No net loss of habitat value while minimizing loss of in-kind habitat values.
Montane hardwood – conifer	Greater western mastiff-bat Flammulated owl Pacific fisher	3	No net loss of habitat value while minimizing loss of in-kind habitat values.
Montane hardwood	Shasta salamander Shasta sideband snail	3	No net loss of habitat value while minimizing loss of in-kind habitat values.
Montane riparian	Shasta hesperian snail Yellow-breasted chat Foothill yellow-legged frog	2	No net loss of in-kind habitat value.
Ponderosa pine	Flammulated owl Shasta salamander	3	No net loss of habitat value while minimizing loss of in-kind habitat values.
Sierran mixed conifer	Flammulated owl Pacific fisher	3	No net loss of habitat value while minimizing loss of in-kind habitat values.
Riverine	Hardhead Rough sculpin Northwestern pond turtle	2	No net loss of in-kind habitat value.
Lacustrine	Osprey Rainbow trout	2	No net loss of in-kind habitat value.

The evaluation species selected for the closed-cone pine - cypress cover-type that would be impacted in the vicinity of Shasta Lake are great horned owl and red-tailed hawk. These species were selected because of the Service's responsibility for their protection and management under the Migratory Bird Treaty Act, and their overall high non-consumptive values to humans. Both species are known to nest in closed-cone pine forests. Therefore, the Service designates the closed-cone pine - cypress cover-type within the Project area as Resource Category 3. Our associated mitigation planning goal for these areas is "no net loss of habitat value while minimizing loss of in-kind habitat value."

Table 11. Resource Categories, Evaluation Species, and Mitigation Planning Goal for the Habitats of the Sacramento River (and Lower Reaches of Tributaries) from Keswick Dam Downstream to the Sacramento – San Joaquin Delta Impacted by the Shasta Lake Water Resources Investigation Project.

Cover-type	Evaluation Species	Resource Category	Mitigation Goal
Shaded Riverine Aquatic Cover	Fall-run Chinook salmon	1	No loss of existing habitat value
Riverine	Fall-run Chinook salmon Hardhead Northwestern pond turtle	2	No net loss of in-kind habitat value.
Oak woodland	Yellow warbler Acorn woodpecker	2	No net loss of in-kind habitat value.
Blackberry scrub	Yellow warbler	2	No net loss of in-kind habitat value.
Great Valley willow scrub	Yellow-breasted chat	2	No net loss of in-kind habitat value.
Great Valley cottonwood riparian forest	Yellow-billed cuckoo Black-headed grosbeak	2	No net loss of in-kind habitat value.
Great Valley mixed riparian forest	Yellow-billed cuckoo Black-headed grosbeak	2	No net loss of in-kind habitat value.
Great Valley valley oak riparian forest	Yellow warbler Song sparrow	2	No net loss of in-kind habitat value.
Freshwater seep	Yellow-breasted chat Common yellowthroat	2	No net loss of in-kind habitat value.
Seasonal wetland	Tricolored blackbird Yellow-breasted chat	2	No net loss of in-kind habitat value.
Estuarine	Longfin smelt Sacramento splittail	2	No net loss of in-kind habitat value.

The evaluation species selected for the mixed chaparral cover-type that would be impacted in the vicinity of Shasta Lake are wrentit and ringtail. The wrentit was selected because it is strongly associated with shrubland habitats including mixed chaparral. The species has also been identified by CalPIF as a focal bird species for the conservation of chaparral habitat. Ringtail was selected because of its association with mixed chaparral habitat and its status as a California Fully Protected species and a CALFED MSCS species. Therefore, the Service designates the mixed chaparral cover-type within the Project area as Resource Category 3. Our associated mitigation planning goal for these areas is "no net loss of habitat value while minimizing loss of in-kind habitat value."

The evaluation species selected for the montane hardwood - conifer cover-type that would be impacted in the vicinity of Shasta Lake are greater western-mastiff bat, flammulated owl, and Pacific fisher. The greater western-mastiff bat was selected because of its association with this habitat type and its status as a CALFED MSCS species. Several bat roosting caves would be inundated by the SLWRI. Flammulated owl was selected because of its association with montane hardwood – conifer habitat and its identification by CalPIF as a focal bird species for conservation. Pacific fisher was selected because of its association with montane hardwood – conifer habitat and its status as a Federal candidate species. Therefore, the Service designates the montane hardwood - conifer cover-type within the Project area as Resource Category 3. Our associated mitigation planning goal for these areas is “no net loss of habitat value while minimizing loss of in-kind habitat value.”

The evaluation species selected for the montane hardwood cover-type that would be impacted in the vicinity of Shasta Lake are Shasta sideband snail and Shasta salamander. Shasta sideband snail was selected because it is endemic to limestone outcrops in the vicinity of Shasta Lake and its status as a USFS Survey and Manage species and a CALFED MSCS species. Shasta salamander was selected because the species is endemic to the vicinity of Shasta Lake and because of its status as a California threatened species and a CALFED MSCS species. Therefore, the Service designates the montane hardwood cover-type within the Project area as Resource Category 3. Our associated mitigation planning goal for these areas is “no net loss of habitat value while minimizing loss of in-kind habitat value.”

The evaluation species selected for the montane riparian cover-type that would be impacted in the vicinity of Shasta Lake are Shasta hesperian snail, yellow-breasted chat, and foothill yellow-legged frog. The Shasta hesperian snail was selected because its range is highly restricted to riparian habitat in the vicinity of Shasta Lake and its status as a USFS Survey and Manage species. The yellow-breasted chat was selected because of its dependence on riparian habitat for breeding, its status as a CALFED MSCS species and a CalPIF focal species, and the Service’s responsibility for their protection and management under the Migratory Bird Treaty Act. Foothill yellow-legged frog was selected because of its dependence on riparian habitat and its status as a CALFED MSCS species. Because of the scarcity of this habitat type and its high value to many sensitive wildlife species, the Service designates the montane riparian cover-type within the Project area as Resource Category 2. Our associated mitigation planning goal for these areas is “no net loss of in-kind habitat value.”

The evaluation species selected for the ponderosa pine cover-type that would be impacted in the vicinity of Shasta Lake are flammulated owl and Shasta salamander. Flammulated owl was selected because of its association with ponderosa pine habitat and its identification by CalPIF as a focal bird species for conservation. Shasta salamander was selected because the species is endemic to the vicinity of Shasta Lake and because of its status as a California threatened species and a CALFED MSCS species. Therefore, the Service designates the ponderosa pine cover-type within the Project area as Resource Category 3. Our associated mitigation planning goal for these areas is “no net loss of habitat value while minimizing loss of in-kind habitat value.”

The evaluation species selected for the Sierran mixed conifer cover-type that would be impacted in the vicinity of Shasta Lake are flammulated owl and Pacific fisher. Flammulated owl was selected because of its association with Sierran mixed conifer habitat and its identification by CalPIF as a focal bird species for conservation. Pacific fisher was selected because of its association with Sierran mixed conifer habitat and its status as a Federal candidate species. Therefore, the Service designates the ponderosa pine cover-type within the Project area as Resource Category 3. Our associated mitigation planning goal for these areas is “no net loss of habitat value while minimizing loss of in-kind habitat value.”

The evaluation species selected for riverine cover-type that would be impacted in the vicinity of Shasta Lake are hardhead, rough sculpin, and northwestern pond turtle. Hardhead was selected because of its status as a CALFED MSCS species and its reliance on riverine habitat to escape predatory centrarchid basses in Shasta Lake. Rough sculpin was selected because the fish species is largely restricted to spring-fed tributaries of the Pit River near the Project area and the potential adverse impacts of the conversion of riverine habitat into lacustrine. The species was selected also because of its status as a California threatened species, a CDFG Fully Protected species, and a CALFED MSCS species. Northwestern pond turtle was selected due to its dependence on stream and wetland habitat throughout the SLWRI Inundation Zone and vicinity and its status as a CALFED MSCS species. Because of the high value of this habitat to many sensitive wildlife species, the Service designates the riverine cover-type within the Project area as Resource Category 2. Our associated mitigation planning goal for these areas is “no net loss of in-kind habitat value.”

The evaluation species selected for lacustrine cover-type that would be impacted within Shasta Lake are osprey and rainbow trout. Osprey was selected because of its status as a CALFED MSCS species and the overall importance of Shasta Lake to the recovery of the species. Rainbow trout was selected because it is the principal game species in Shasta Lake and its tributaries. Because of the high value of this habitat to many sensitive wildlife and game species, the Service designates the lacustrine cover-type within the Project area as Resource Category 2. Our associated mitigation planning goal for these areas is “no net loss of in-kind habitat value.”

SRA cover is defined as the nearshore aquatic area occurring at the interface between a river (or stream) and adjacent woody riparian habitat. The principal attributes of this valuable cover-type include: (a) the adjacent bank being composed of natural, eroding substrates supporting riparian vegetation that either overhangs or protrudes into the water, and (b) the water containing variable amounts of woody debris, such as leaves, logs, branches and roots, as well as variable depths, velocities, and currents (USFWS 1992). Due to the scarcity and high value of SRA cover to an array of fish and wildlife species, the Service classified all areas of SRA cover existing along the following major riverine channels of the Sacramento River system within the Sacramento Valley, California, as Resource Category 1 (USFWS 1992): (1) the Sacramento River, from Keswick Dam (River Mile 302) downstream to Rio Vista (River Mile 13); (2) the Sacramento River’s four primary distributary channels---Steamboat, Miner, Sutter, and Georgiana sloughs---which branch off the main river downstream of the city of Sacramento, roughly between the towns of Clarksburg and Walnut Grove; (3) the Feather River, from Oroville Dam downstream to the confluence with the Sacramento River; (4) the Yuba River, from Engelbright Dam downstream to the confluence with the Feather River; and (5) the American River, from Nimbus Dam downstream to the confluence with the Sacramento River (USFWS 1992).

The evaluation species selected for SRA cover that would be impacted is fall-run Chinook salmon. Overhanging vegetation in SRA cover moderates water temperatures, which is an important factor for all life stages of salmonid fishes. The vegetation provides food and habitat for both terrestrial and aquatic invertebrates, which in turn serve as food for numerous bird species and several fish species including Chinook salmon and steelhead trout (Hydrozoology 1976, Sekulich and Bjornn 1977, Rondorf *et al.* 1990, Sommer *et al.* 2001b, Winemiller and Jepsen 1998, Cannon 2007). Based on the high value, uniqueness, and irreplaceability of SRA cover for the evaluation species, the Service has determined SRA cover which would be affected by the project should be placed in Resource Category 1, with an associated mitigation planning goal of “no loss of existing habitat value.”

The evaluation species selected for riverine cover-type that would be impacted in the Sacramento River between Keswick Dam and the Sacramento-San Joaquin Delta are fall-run Chinook salmon, hardhead, and northwestern pond turtle. Fall-run Chinook salmon was selected because of its commercial importance, and it is a target species that the SLWRI is expected to benefit by enlarging the cold water pool at Shasta Dam to maintain colder temperatures in the Sacramento River upstream of the RBDD. Hardhead was selected because of its status as a CALFED MSCS species and the potential for adverse effects of the SLWRI on it and other warmer water native fish species by maintaining colder temperatures in the Sacramento River upstream of the RBDD. Most streams in which hardhead occur have summer temperatures in excess of 20^{o}C (68^{o}F), and optimal temperatures for hardhead appear to be 24-28^{o}C (75.2-82.4^{o}F) (Moyle 2002). Northwestern pond turtle was selected to represent off channel habitat and because of its status as a CALFED MSCS species. Because of the high value of this habitat to many sensitive and commercially important aquatic species, the Service designates the riverine cover-type within the Project area from Keswick Dam downstream to the Delta as Resource Category 2. Our associated mitigation planning goal for these areas is “no net loss of in-kind habitat value.”

The evaluation species selected for oak woodland cover-type that would be impacted along the Sacramento River are acorn woodpecker and yellow warbler. Acorn woodpeckers utilize oak woodlands for nearly all their life requisites; 50-60 percent of the acorn woodpecker’s annual diet consists of acorns. Acorn woodpeckers can also represent impacts to other canopy-dwelling species. Yellow warbler abundance is positively associated with the abundance of valley oak in the Sacramento Valley (RHJV 2004). Thus, the Service has selected acorn woodpecker and yellow warbler because of their dependence on oak woodland habitat and the status of yellow warbler as a CALFED MSCS species. Because of the valley oak and blue oak component of the oak woodland cover-type and their significance to yellow warbler, the Service has designated these areas as Resource Category 2. Our associated mitigation planning goal for these areas is “no net loss of in-kind habitat value.”

The evaluation species selected for blackberry scrub cover-type that would be impacted along the Sacramento River is yellow warbler. Yellow warbler abundance is positively associated with the occurrence of blackberry in riparian habitat of the Sacramento Valley (RHJV 2004). Thus, the Service has selected yellow warbler because of its dependence on blackberry scrub and its status as a CALFED MSCS species. Because of the importance of blackberry scrub for yellow warbler and other riparian obligate species, the Service has designated these areas as Resource Category 2. Our associated mitigation planning goal for these areas is “no net loss of in-kind habitat value.”

The evaluation species selected for Great Valley willow scrub cover-type that would be impacted along the Sacramento River is yellow-breasted chat. Yellow-breasted chat abundance is positively associated with sandbar willow, a component species of Great Valley willow scrub (RHJV 2004). Because of the importance of Great Valley willow scrub for yellow-breasted chat and other riparian obligate species and the status of yellow-breasted chat as a CALFED MSCS species, the Service has designated these areas as Resource Category 2. Our associated mitigation planning goal for these areas is “no net loss of in-kind habitat value.”

The evaluation species selected for Great Valley cottonwood riparian forest and Great Valley mixed riparian forest cover-types that would be impacted along the Sacramento River are black-headed grosbeak and yellow-billed cuckoo. Black-headed grosbeak was selected because the species' abundance and occurrence is positively associated with Fremont cottonwood presence and tree species richness, respectively, which are important components of Great Valley cottonwood riparian forest and Great Valley mixed riparian forest cover-types (RHJV 2004). Black-headed grosbeak was identified by RHJV as a focal bird species for the conservation of riparian habitat (RHJV 2004). Yellow-billed cuckoo was selected because of its dependence on cottonwood-willow riparian habitat and its status as a California endangered species, a Federal candidate species, and a CALFED MSCS species. In California, there are only about 30 breeding pairs of yellow-billed cuckoo with 23 – 25 pairs occurring in the Sacramento River between Red Bluff and Colusa (Laymon and Halterman 1989, Halterman 1991). Yellow-billed cuckoos require large patches of cottonwood-willow riparian habitat with high canopy cover and foliage volume, and moderately large and tall trees. Additionally, the Service has responsibility for the protection and management of both bird species under the Migratory Bird Treaty Act. Because of the significance of the habitat to yellow-billed cuckoo and other riparian obligate species, the Service has designated these areas as Resource Category 2. Our associated mitigation planning goal for these areas is "no net loss of in-kind habitat value."

The evaluation species selected for Great Valley valley oak riparian forest cover-type that would be impacted along the Sacramento River are yellow warbler and song sparrow. Yellow warbler and song sparrow abundance are positively associated with the presence of valley oak in the Sacramento Valley (RHJV 2004). Both species are identified by RHJV as focal bird species for the conservation of riparian habitat (RHJV 2004). Yellow warbler has special status as a CALFED MSCS species. Additionally, the Service has responsibility for the protection and management of both bird species under the Migratory Bird Treaty Act. Thus, because of the significance of Great Valley valley oak riparian forest to riparian obligate species, the Service has designated these areas as Resource Category 2. Our associated mitigation planning goal for these areas is "no net loss of in-kind habitat value."

The evaluation species selected for freshwater seep cover-type that would be impacted along the Sacramento River are yellow-breasted chat and common yellowthroat. The presence of sedges has a positive influence on the abundance of both bird species (RHJV 2004). Yellow-breasted chat has special status as a CALFED MSCS species. Additionally, the Service has responsibility for the protection and management of both bird species under the Migratory Bird Treaty Act. Thus, because of the scarcity of freshwater seep habitat and its significance to yellow-breasted chat and common yellowthroat, the Service has designated these areas as Resource Category 2. Our associated mitigation planning goal for these areas is "no net loss of in-kind habitat value."

The evaluation species selected for seasonal wetland cover-type that would be impacted along the Sacramento River are tricolored blackbird and yellow-breasted chat. Both species are CALFED MSCS species. Additionally, the Service has responsibility for the protection and management of both bird species under the Migratory Bird Treaty Act. Thus, because of the scarcity of seasonal wetland habitat and its significance to tricolored blackbird and yellow-breasted chat, the Service has designated these areas as Resource Category 2. Our associated mitigation planning goal for these areas is "no net loss of in-kind habitat value."

The evaluation species selected for estuarine habitat that would be impacted in the Sacramento-San Joaquin Delta are longfin smelt and Sacramento splittail. Both fish species are highly dependent on the Sacramento-San Joaquin Delta estuarine habitat for their survival. The CALFED Final EIR/EIS and CALFED ROD (CALFED 2000a,b) state that CALFED actions must “recover both species’ populations within the MSCS focus area to levels that ensure the species’ long-term survival in nature.” Longfin smelt is currently proposed for Federal listing under ESA. The species has declined to 3 percent of its historic levels; its abundance has been at record lows for the past 4 years (CDFG 2007c,e). Because of the dependence of longfin smelt, Sacramento splittail, and other estuarine species on the Sacramento-San Joaquin Delta, the Service has designated these areas as Resource Category 2. Our associated mitigation planning goal for these areas is “no net loss of in-kind habitat value.”

RESULTS AND DISCUSSION

Anadromous Fish

The primary objectives of the SLWRI are increasing Water Supply Reliability and Anadromous Fish Survival with Ecosystem Restoration as a secondary objective. Five alternatives were developed to address the objectives of the SLWRI by raising Shasta Dam 6.5 feet (CP1), 12.5 feet (CP2), or 18.5 feet (CP3, CP4, and CP5) and modifying the TCD to maintain cooler temperatures for anadromous fish spawning and rearing habitat in the Sacramento River between Keswick Dam and the RBDD. CP4 included dedicating 378,000 af of the increased storage for cold water reserves. All five of the SLWRI alternatives provided benefits for increased Water Supply Reliability, but only one alternative (CP4) achieved measurable benefits to Anadromous Fish Survival. However, even in CP4, the benefits of an enlarged cold water pool for Anadromous Fish Survival would be limited to a few dry and critically dry water years representing 5 – 15 percent of the water years 1922 – 2002 simulation period.

Salmod modeling of the No Action alternative reveals that thermal mortality to winter-, fall-, and late fall-run Chinook salmon (exceeding 2 percent) in the Sacramento River between Keswick Dam and the RBDD is limited to a few dry and critically dry water years representing 9 percent of the years simulated (Appendix B). Salmod modeling also shows that in the vast majority of years, the predominate sources of mortality to anadromous fish in the Sacramento River in No Action are superimposition, habitat constraints, the flushing or dewatering of redds, and entrainment in unscreened water diversions (Appendix B). Initially, the SLWRI alternatives included other measures to address the objectives of Anadromous Fish Survival and Ecosystem Restoration. These measures included riparian and floodplain restoration, gravel augmentation, increasing minimum flows, screening water diversions, improving fish passage, and removal of invasive species. However, all of these restoration measures were removed by Reclamation from further consideration except for unspecified restoration around Shasta Lake in CP5 (USBR 2006a, 2007a). The Service believes that in order to adequately address the primary objective of Anadromous Fish Survival and the secondary objective of Ecosystem Restoration, Reclamation should reincorporate these restoration measures into the SLWRI alternatives. The inclusion of these restoration measures would likely result in a decrease in mortality of anadromous fish in the Sacramento River due to superimposition, habitat constraints, the flushing or dewatering of redds, and entrainment in unscreened water diversions. This would result in benefits to Anadromous Fish Survival during all years instead of being limited to a few dry and critically dry water years representing 9 percent of the period of record. The restoration of floodplain and riparian habitat and removal of invasive species would have the added benefit of providing important nesting habitat for raptors and migratory birds including the rare yellow-billed cuckoo.

The Salmod modeling results for the SLWRI show the greatest benefit of the enlarged cold water pool in CP4 is the reduction in thermal mortality of spring-run Chinook salmon eggs (Figures B-17A, B-17B, B-19B, and B-19D in Appendix B). However, Service believes that the Salmod modeling likely overestimates the benefits of the enlarged cold water pool to spring-run Chinook salmon. In a February 3, 2006, letter to Reclamation regarding Salmod, CDFG stated:

> *There is doubt that a distinct spring-run Chinook salmon population still spawns in the main-stem upper Sacramento River, because spawn timing and areas*

overlap with fall-run Chinook spawning. However, main-stem and tributary rearing habitat for juvenile spring-run Chinook should still be considered for known tributary populations including Clear Creek, Battle Creek, Beegum Creek, Antelope Creek, Mill Creek, Deer Creek and Butte Creek (Koch in litt. 2006).

In January 2007, a CDFG fish biologist reiterated that:

We [CDFG] consider the spring-run in the mainstem to be hybridized with the much more numerous fall-run and the Department [CDFG] thinks NO unique spring-run population currently exists in the mainstem. We [CDFG] consider there to be no unique population of Sacramento River mainstem spring-run. Rather each year a variable number of straying spring-run find their way to the upper Sacramento River near Redding and spawn with the fall-run (Killam in litt. 2007).

Additionally, Service has pointed out to Reclamation that Salmod modeling currently overestimates the number of spring-run spawners returning to the mainstem Sacramento River (M. Brown, Red Bluff FWO, pers. comm., 2007). Therefore, Service believes that the Salmod modeling results in the SLWRI overstate the benefits that the SLWRI would provide for spring-run Chinook salmon.

Another source of error in the Salmod modeling for the SLWRI is the inability to simulate resource competition among the four runs of Chinook salmon and steelhead in the mainstem Sacramento River and the lower reaches of the tributaries. Bartholow (2003) states about the development of the Salmod model, ". . . I assumed that the four races do not use, and compete for, the same microhabitat at the same time." CDFG responded in their February 3, 2006, letter to Reclamation regarding the Salmod modeling:

We [CDFG] believe this assumption is an over-simplification because it implies that juveniles of each Chinook race sequentially use rearing habitat in the upper river and have no overlap in residence period. Chinook juveniles of all sizes and multiple races rear in the upper river year-round and should be addressed in the model (Koch in litt. 2006).

Bruce Oppenheimer, NOAA Fisheries fish biologist, agreed that resource competition and predation among the four runs of Chinook salmon and steelhead, in particular, was an important source of mortality of Chinook salmon fry and pre-smolts in the Sacramento River (B. Oppenheimer, NOAA Fisheries, pers. comm., 2007). Therefore, the Service believes that the Salmod modeling in the SLWRI underestimates the mortality of Chinook salmon fry, pre-smolts, and immature smolts (of spring-run and late fall-run especially) due to predation, resource competition, and habitat constraints. Salmod also likely underestimates mortality of spring-run eggs due to superimposition by the more numerous fall-run.

<u>Rare Species in the Vicinity of Shasta Lake</u>

The Service believes that the SLWRI would result in adverse affects to rare and special-status species within the vicinity of Shasta Lake. The raising of Shasta Lake would inundate the limited habitat of the following seven rare, but not federally listed, species each of which is endemic to the vicinity of Shasta Lake: Shasta snow-wreath, Shasta salamander, Shasta sideband snail, Wintu sideband snail, Shasta chaparral snail, Shasta hesperian snail, and a rare undescribed variety of red huckleberry unofficially known as "Shasta huckleberry" (Lindstrand and Nelson 2005a,b; NSR 2004; Lindstrand 2007; DeWoody and Hipkins 2007; J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007). Additional habitat would be disturbed by construction-related activities and the relocation of campgrounds, roads, bridges, and other facilities above the Inundation Zone. The raising of Shasta Dam and implementation of the SLWRI would result in the loss, degradation, and fragmentation of habitat and as a result, may require further evaluation by the Service of the factors threatening these seven species pursuant to section 4 of the ESA.

The rare terrestrial mollusks Shasta sideband and Wintu sideband are restricted to limited limestone outcrops in the vicinity of Shasta Lake (Lindstrand 2007); therefore, a significant portion of their habitat would be lost due to inundation or disturbance by the SLWRI. The ranges of the Shasta sideband and Wintu sideband are restricted to limestone outcrops along the McCloud and Pit River arms, respectively, in the vicinity of Shasta Lake (Lindstrand 2007). The CALFED Final Programmatic EIS/EIR (CALFED 2000a,b) states that CALFED actions, such as the SLWRI, should not threaten the population viability of the Shasta sideband and must maintain the current status of the species.

Shasta snow-wreath would especially be threatened by the raising of Shasta Dam—nine of only 21 known occurrences of the plant species (43 percent) would be partly or completely lost within the Inundation Zone with potentially others being affected by construction activities associated with the relocation of campgrounds, marinas, roads, bridges, and other facilities (Lindstrand and Nelson 2005a,b; NSR 2004; Lindstrand 2007). Another eight occurrences of Shasta snow-wreath (38 percent) are threatened by non-project related activities due to their locations near roads, trails, and logging areas (Lindstrand 2007). Thus, only four occurrences of the Shasta snow-wreath (19 percent) are not currently threatened by the SLWRI or non-project related activities (Lindstrand 2007). At this time, the genetic diversity of the Shasta snow-wreath plants is not known; further genetic analysis is required to determine what genetic diversity would be lost due to the SLWRI (J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007). The CALFED Programmatic EIS/EIR includes Shasta snow-wreath among a list of "evaluated species for which direct mortality as a result of implementing CALFED actions is prohibited as a condition of the Multi-Species Conservation Strategy" (Table 4-5 in MSCS section of CALFED 2000b).

Shasta salamander, Shasta chaparral snail, and Shasta hesperian snail are also endemic to the vicinity of Shasta Lake and would thus lose a significant portion of their habitat within the Inundation Zone. Additional habitat would be permanently or temporarily lost due to the relocation of campgrounds, marinas, roads, bridges, and other facilities to areas beyond the Inundation Zone.

Shasta huckleberry is known from only 3 locations all in the vicinity of Shasta Lake. The plant appears to have adapted to the low pH soils with unique mineral compositions associated with abandoned mine sites in the Western Shasta Mining District (J. Nelson, pers. comm. 2007). Nine Shasta huckleberry shrubs would be lost within the Inundation Zone in the lower Little Backbone Creek drainage (DeWoody and Hipkins 2007; J. Nelson, Shasta-Trinity National Forest, pers.

comm., 2007). Another population of Shasta huckleberry is currently threatened by non-project related ground disturbing activities associated with soil remediation on private land near the Bully Hill abandoned mine site (L. Lindstrand, NSR, pers. comm., 2007). It is not known at this time what percent of the total number of Shasta huckleberry plants would be lost due to the SLWRI and non-project related activities. Further genetic analysis is required to determine whether Shasta huckleberry is genetically distinct from the closely related red huckleberry which grows in a more mesic climate under different soil types 40 miles away.

The western purple martin, although not endemic to Shasta County, would lose essential nesting habitat along the Pit River arm. Although new snags would be created by the inundation of trees within the Inundation Zone, there would likely be a time lag of decades before the newly inundated snags would provide suitable nesting habitat for the western purple martin (Lindstrand 2007; G. Bolen , NSR, pers. comm., 2007). Thus the western purple martin may abandon its essential nesting habitat along the Pit River arm and not return (Lindstrand 2007; G. Bolen, NSR, pers. comm., 2007). Currently, there are 18 known nesting pairs of western purple martin in the Pit River arm that may be affected by the SLWRI (Lindstrand 2007). Shasta Lake represents 14 – 51 percent of the total interior northern California population of western purple martins (Williams 1998).

Other special-status species that would be affected by habitat loss within the Inundation Zone include the bald eagle, northern spotted owl, and the Pacific fisher.

Sacramento River and the Delta

The raising of Shasta Dam in the SLWRI would also likely affect riparian and aquatic habitat along the Sacramento River from Keswick Dam all the way to the Sacramento-San Joaquin River Delta. The CALSIM modeling which is based on monthly timesteps likely underestimates the effects of the SLWRI alternatives on flooding events which operate on daily and weekly timesteps. Changes in the timing, intensity, and frequency of flood flows in the Sacramento River would inhibit the fluvial processes essential for sediment transport and the establishment and maintenance of a diverse mixed-aged riparian habitat. Flooding is essential for the establishment of mixed-age riparian habitat that is important to special-status migratory birds along the Sacramento River including the rare yellow-billed cuckoo. A decrease in spring flood flows would decrease the establishment of native riparian vegetation while increasing the establishment of exotic species (Little 2007). Native riparian vegetation is also important for providing SRA cover and the recruitment of large woody debris essential for juvenile salmonid rearing habitat in the Sacramento River. In fact, snorkeling studies in the Sacramento River show that the lack of suitable juvenile rearing habitat in the middle Sacramento River (*i.e.*, river miles 180 – 230 (a few miles downstream from Ord Ferry up to the Elder Creek)) is likely the most limiting factor for Chinook salmon survival in the Sacramento River; only 1 percent of this reach of the middle Sacramento River is suitable rearing habitat for juvenile Chinook salmon (Cannon 2007).

Additionally, a decrease in spring flood flows with the SLWRI would result in a decrease in nesting survival of riparian songbirds such as the black-headed grosbeak due to an increase in the activity of mammalian predators during the songbird’s breeding season (Small 2007). A decrease in flood flows would also reduce the flooding of the Yolo Bypass which is important rearing habitat for juvenile salmonids, Sacramento splittail, and longfin smelt (Sommer *et al.* 2001a,b). Decreasing flood flows would also affect Delta aquatic species such as delta smelt, Sacramento splittail, and juvenile salmonids by decreasing flushing flows, and changing the location of the freshwater-saltwater mixing zone (X2). The SLWRI alternatives also resulted in an increase in Delta exports during critically dry water years which would increase the entrainment of delta smelt and other fish species at the Tracy and Banks pumping facilities.

Guidelines for Definition of the No Action Alternative

The Service believes the following activities are expected to take place, or should occur, with or without Shasta Lake expansion: (1) new rules for OCAP, (2) continued implementation of water use efficiency and conservation (*e.g.*, increased irrigation efficiency in the Anderson Cottonwood Irrigation District (ACID)), (3) Joint Point of Diversion exchanges between the CVP/SWP, (4) water transfers, (5) recycling, (6) Delta-Mendota Canal/California Aqueduct Intertie, and (7) Banks Pumping Plant expansion. These ongoing and anticipated projects should be included in modeling for all SLWRI alternatives, including the No Action. To date within SLWRI planning documents reviewed by the Service, it is not clear how or if these activities were considered in modeling efforts.

In addition, the Service believes that without the SLWRI the Federal Government would take additional actions to help increase anadromous fish survival in the upper Sacramento River as required by the CVPIA, the SWRCB Order 90-5, the 1993 biological opinion for winter-run Chinook salmon (NOAA Fisheries 1993), and Senate Bill 1086. The AFRP Restoration Plan (USFWS 2001) was developed to comply with Section 3406(b)(1) of the CVPIA.

The AFRP Restoration Plan (USFWS 2001) identifies several high priority actions for increasing anadromous fish survival in the upper Sacramento River including the following: (1) implementing a river flow regulation plan that balances carryover storage needs with instream flow; (2) maintaining water temperatures at or below 56^{o}F from Keswick Dam to Bend Bridge; (3) creating a meander belt from Keswick Dam to Colusa to recruit gravel and large woody debris, to moderate temperatures and to enhance nutrient input; (4) restoring and replenishing spawning gravel, where appropriate, in the Sacramento River; (5) evaluate opportunities to incorporate flows to restore riparian vegetation from Keswick Dam to Verona that are consistent with the overall river regulation plan; and (6) identify opportunities for restoring riparian forests in channelized section of the upper mainstem Sacramento River that are appropriate with flood control and other water management constraints.

Passed by the State Legislature in 1986, Senate Bill 1086 called for a management plan for the Sacramento River and its tributaries that would protect, restore, and enhance both fisheries and riparian habitat. The law established an Advisory Council, composed of representatives of state and federal agencies, county supervisors, and representatives of landowner, water contractor, commercial and sport fisheries, and general wildlife and conservation interests. In compliance with Senate Bill 1086, the SRCAF developed a handbook (SRCAF 2003) which identifies guidelines for the restoration of the various reaches of the Sacramento River. For the Keswick Dam – RBDD reach, SRCAF recognizes the following restoration priorities: (1) protect physical processes where still intact; (2) allow riparian forest to reach maturity; (3) restore physical and successional processes; and (4) conduct reforestation activities. Therefore, in the likely future condition without the SLWRI, some restoration of the Sacramento River is to be expected in line with the goals and mandates of CVPIA, AFRP, and SRCAF.

Conclusion

The primary objectives of the SLWRI as stated in the PFR (USBR 2007) are increasing Water Supply Reliability and Anadromous Fish Survival with a secondary objective of Ecosystem Restoration. Of the 5 alternatives evaluated by the SLWRI, all 5 alternatives provide benefits to Water Supply Reliability. However, only 1 alternative (CP4) provides measurable benefits to Anadromous Fish Survival, but these benefits are limited to a few dry and critically dry water years representing less than 10 percent of the simulation period. The initial alternatives included multiple restoration opportunities to address both Anadromous Fish Survival and Ecosystem Restoration (*e.g.*, riparian habitat restoration, spawning gravel augmentation, removal of barriers to fish passage, screening water diversions to prevent entrainment, and removal of invasive species); however, all of the restoration opportunities were removed by Reclamation from further consideration except for unspecified environmental restoration around Shasta Lake in CP5. The Service believes that the environmental restoration around Shasta Lake in CP5 would likely be included as a mitigation measure for the inundation and disturbance of habitat around the lake regardless.

The SLWRI would inundate the limited habitat of 8 rare species (*e.g.*, Shasta snow-wreath, Shasta salamander, Shasta sideband snail, Wintu sideband snail, Shasta chaparral snail, Shasta hesperian snail, Shasta huckleberry, and western purple martin) 7 of which are endemic to the vicinity of Shasta Lake. Additional habitat would be disturbed by the relocation of campgrounds, roads, bridges, and facilities beyond the Inundation Zone. Thus, the raising of Shasta Dam and implementation of the SLWRI would result in the loss, degradation, and fragmentation of habitat and as a result, may require further evaluation by the Service of the factors threatening these 8 species pursuant to section 4 of the ESA. Additionally, the reduction in winter flows with the raising of Shasta Dam would result in adverse affects to riparian habitat along the Sacramento River and to sensitive aquatic species in the Delta.

In the SLWRI PFR, Reclamation allocates 61.2 percent ($505 million) of the total construction cost of CP4 to “Fish and Wildlife Enhancement” (Table 6-6 in USBR 2007). However, based on the minimal benefits afforded to anadromous fish, the adverse affects of the project to 8 rare species in the vicinity of Shasta Lake, and the impacts of reduced winter flows to riparian and estuarine habitat in the Sacramento River and the Delta, the Service believes that the benefits to “Fish and Wildlife Enhancement” do not equate to 61.2 percent ($505 million) of the cost of the SLWRI. Additionally, the $505 million that would be required to fund “Fish and Wildlife Enhancement” in the SLWRI would likely be diverted from other more cost effective environmental restoration projects identified as high priority goals for anadromous fish survival and riparian restoration by AFRP, SRCAF, and RHJV.

Additional Information Required

More information is required related to the following before the Service can complete its analysis of the effects of the SLWRI on fish and wildlife resources:

- Details on habitat disturbance associated with each of the SLWRI alternatives;

    1. Location of aggregate mining and staging areas

    2. Relocation of campgrounds, roads, bridges, marinas, etc. beyond the Inundation Zone

    3. Acreage of each habitat type permanently or temporarily lost or disturbed

- Ecosystem restoration defined in CP5;

- CALSIM or other hydrological modeling data;

    1. Effects of the SLWRI alternatives on daily flows in the Sacramento River and the flooding of the Yolo and Sutter Bypasses

    2. An analysis of the effects of the SLWRI on the Delta (*e.g.*, X2 location and inflow/export ratios)

    3. Sensitivity runs with and without NODOS (Sites Reservoir)

    4. Evaluation of other proposed CALFED water storage projects

    5. Changes in the operation of other CVP/SWP dams and effects on temperature and flows downstream

    6. Analysis of the capability of improving temperature and flow conditions for anadromous fish in the Sacramento River without raising Shasta Dam

        - Modifications to the TCD
        - Operational changes at Shasta Dam
        - Riparian restoration associated with AFRP and SRCAF

- Analysis of the effects of the SLWRI on Sacramento River riparian and aquatic habitat species (*e.g.*, cottonwood, northwestern pond turtle, Chinook salmon, steelhead, green sturgeon, bank swallow, and other CALFED MSCS species) through the application of a daily physical model such as SacEFT (ESSA Technologies Ltd. 2006) or Reclamation-Denver's Physical River model;

- HEP data;

    1. Lacking data on acreage of each habitat type that would be lost or disturbed for each of the SLWRI alternatives

    2. Lack mitigation sites

- Mitigation;

1. Potential mitigation sites

2. Avoidance and minimization measures

3. Conservation measures

- USFS Survey and Manage Species (*e.g.*, Shasta snow-wreath, Shasta chaparral snail, Shasta hesperian snail, Shasta sideband, Wintu sideband, Shasta salamander, and various species of bats) and CALFED MSCS species;

    1. Current distribution and population

    2. Number of individuals and/or percent of the population and habitat that would be lost or disturbed

    3. Habitat fragmentation

    4. Evaluation of the potential for Federal listing under ESA

- Genetic analysis of Shasta snow-wreath and Shasta huckleberry populations to determine the genetic diversity that would be lost and whether the rare Shasta huckleberry is genetically distinct from the coastal red huckleberry populations;

- Data on location of abandoned mines and effects of inundation;

- Analysis of the effects of inundation of riverine habitat and conversion to lacustrine;

- Effects of the project on invasive species (*e.g.*, New Zealand mud snail, exotic plants) and plans to minimize their spread;

- Effects of climate change;

- Monitoring and adaptive management plan.

MITIGATION

Mitigation has not yet been addressed by Reclamation for the SLWRI alternatives.

RECOMMENDATIONS

Based on the information currently provided by Reclamation in the Plan Formulation Report (USBR 2006a, 2007a), the Service has the following recommendations. Additional CALFED conservation measures for species- and cover-types are identified in Appendix D of this report (CALFED Multi-Species Conservation Strategy species and habitat types).

I. Guidelines for Definition of the No Action Alternative

Reclamation should include in the No Action Alternative the following activities that are expected to take place, or should occur, with or without Shasta Lake expansion:

A. New rules for OCAP.

B. Continued implementation of water use efficiency and conservation (*e.g.*, increased irrigation efficiency in the Anderson Cottonwood Irrigation District (ACID)).

C. Joint Point of Diversion exchanges between the CVP/SWP.

D. Water transfers.

E. Water recycling.

F. Delta-Mendota Canal/California Aqueduct Intertie.

G. Banks Pumping Plant expansion.

H. Some of the high priority restoration actions identified by CVPIA and State Senate Bill 1086 for riparian restoration and increasing anadromous fish survival in the Sacramento River and tributaries (*e.g.,* AFRP Restoration Plan (USFWS 2001) and SRCAF (SRCAF 2003)).

II. Anadromous Fish Survival without Raising Shasta Dam.

Reclamation should evaluate the capability of increasing the survival of anadromous fish and water supply reliability without raising Shasta Dam. This could be accomplished through an additional alternative including the following:

A. Modifying the existing TCD to improve temperature control.

B. Improving spawning habitat by gravel augmentation in addition to required mitigation levels.

C. Improving juvenile salmonid rearing habitat through large woody debris and riparian restoration (i.e. SRA cover) in the Keswick – RBDD reach, in the lower reaches of the nonnatal tributaries, and in the Sacramento River downstream from RBDD in addition to mitigation levels required by other programs (i.e., CALFED and CVPIA).

D. Operational changes to Shasta Dam to increase cold water storage and/or increase minimum flows.

E. Increasing water use efficiency (e.g., improve irrigation efficiency in the ACID canal).

F. Considering conjunctive use of other existing and planned water storage facilities in the Central Valley.

III. Suggested Modifications to CP4 (in addition to mitigation identified and/or required by other programs (*i.e.*, CALFED and CVPIA)).

In the SLWRI alternatives as currently defined, the only measures remaining that address the primary objective of Anadromous Fish Survival are increasing the size of the cold water pool and modification of the TCD. Only in one alternative (CP4) does increasing the size of the cold water pool provide any significant benefits to anadromous fish survival. However, even in CP4, benefits to winter-, fall, and late fall-run Chinook salmon are limited to a few dry and critically dry water years representing only 9 percent of the October 1922 – September 2003 simulation period. The secondary objective Ecosystem Restoration has been dismissed from all alternatives except for "restoration around Shasta Lake" in CP5 that would likely be recommended for mitigation anyway. The Service recommends that the following be included in the CP4 alternative to better address the primary and secondary objectives of Anadromous Fish Survival and Ecosystem Restoration. Suggestions for modifying CP4 are below and include restoration goals from the SRCAF Handbook (SRCAF 2003), AFRP Final Restoration Plan (USFWS 2001), and the RHJV Bird Conservation Plan (RHJV 2004). Many of these recommendations were originally included in the SLWRI "Alternatives Considered but Removed from Further Analysis" (*e.g.,* AFS-1, AFS-2, AFS-3). The Service recommends that Reclamation reconsider the resource management measures and alternatives that were removed from further analysis. Reclamation should consider the following recommendations for incorporation into CP4 in addition to mitigation that is already identified and/or required by other programs (*e.g*., CALFED and CVPIA):

A. Restore the riparian corridor along mainstem Sacramento River and the lower reach of nonnatal tributaries (see SRCAF 2003, RHJV 2004, USFWS 2001) using the following actions:

1. Restore and protect a diversity of riparian successional states focusing on maintaining wide corridors with adjacent upland habitat along mainstem Sacramento River and lower reaches of nonnatal tributaries.

2. Prioritize restoration sites according to their proximity to existing high-quality sites (*e.g.*, La Barranca site).

3. Leave the gates out year-round at RBDD and restore riparian habitat within the footprint of the existing reservoir from RBDD to 2 miles upstream as the Service also recommended in the FWCA report for the Red Bluff Fish Passage Improvement Project (USFWS 2008).

4. Restore juvenile salmonid rearing habitat along middle Sacramento River (between RBDD and Colusa).

5. Facilitate natural restoration of cottonwood and willow riparian habitat by allowing 3 - 5-year flood events during spring seed dispersal followed by a slow decline in river stage to insure successful germination; however, pulse flows should avoid artificially raising the stage 2 - 3 feet during the bank swallow nesting season (April – July).

6. Actively restore valley oak woodland and elderberry savanna riparian habitat focusing on establishing a wide continuous riparian corridor.

7. Control and eradicate non-native plant species (*e.g., Arundo donax*). Such control is best planned and implemented on a watershed scale.

8. Restore meanders and oxbows.

9. Set-back levees.

10. Relocate low man-made berms to higher ground.

11. Restore riparian areas along the lower reaches of smaller intermittent nonnatal tributaries (*e.g.*, Churn Creek) that provide important rearing habitat for juvenile salmonids that emerged as fry within in the Sacramento River between Keswick Dam and RBDD. Intermittent tributaries are important rearing habitat for juvenile salmonids because the warmer temperatures and pulses of organic matter inputs accelerate the growth rate of juvenile salmonids (Maslin et al. 1996, 1997, 1998, 1999).

12. Protect physical processes where the natural hydrology is still intact through conservation easements or landowner participation *(e.g.*, RM 270-272 near Bend; Red Bluff – Chico Landing Reach; and RM 144-176 of the Chico Landing – Colusa Reach; conservation easement and riparian restoration next to the La Barranca site along the Sacramento River).

13. Protect, enhance or recreate natural riparian processes, particularly hydrology and associated high water events, to promote the natural cycle of channel movement, sediment deposition, and scouring that create a diverse mosaic of riparian vegetation types.

14. As much as possible, manage flow to align with the near natural hydrograph (*i.e.*, mimic natural flood events) sufficient to support scouring, deposition, and point bar formation. However, pulse flows should be time managed to avoid detrimental impacts on bank swallow nesting colonies and should not artificially raise levels more than 2-3 feet during the breeding season (April – July) (RHJV 2004).

15. Prioritize restoration sites according to surrounding land use. For example, suitable adjacent land uses include wilderness areas, unimproved parks/open space provided substantial invasive species issues do not exist, grazed oak woodlands, and timber

production forests. To minimize the effects of predators and cowbird parasitism on breeding habitat for migratory birds, restoration sites should not be near intensive urban/suburban development, rural homes/ranchettes, manicured parks and golf course, dairies, intensive feedlots, and active livestock grazing (RHJV 2004). Brown-headed cowbirds may commute more than 12 kilometers between foraging grounds and the nest sites of their hosts (Mathews and Gougen 1997).

16. Work cooperatively with agricultural researchers to assess the potential of agriculture adjacent to existing riparian areas to be more "bird friendly."

17. Ensure that the patch size, configuration, and connectivity of restored riparian habitats adequately support the desired populations of riparian dependent species.

18. Restore and manage riparian forests to promote structural diversity and volume of the understory.

19. Limit restoration activities and disturbance events such as grazing, disking, herbicide application, and highwater events to the nonbreeding season. When such actions are absolutely necessary during the breeding season, time disturbance to minimize its impacts on nesting birds (RHJV 2004).

B. Using increased storage, increase minimum flows in the upper Sacramento River from the current 3,250 cfs to 4,000 cfs Oct 1 - Apr. 30, if end-of-September storage is 2.4 million af or greater (per the AFRP Final Restoration Plan).

C. Clarify whether and quantify the extent that the cold water pool (378,000 af) in CP4 would be used to augment flows to provide additional benefits for fish and wildlife species. Specify the authority for those augmented flows, and identify if those flows would be at the discretion of the Service, NOAA Fisheries, and CDFG.

D. Monitor and adaptively manage to guide restoration efforts. Conduct intensive, long-term monitoring (including bird monitoring) at selected sites. In order to analyze trends, long-term monitoring should continue for more than 5 years.

E. Augment gravel in the mainstem Sacramento River and lower reaches of tributaries (*e.g.*, Cottonwood Creek).

F. Collaborate with the Anadromous Fish Screen Program to screen diversions and improve fish passage in mainstem Sacramento River and the lower reach of nonnatal tributaries (*e.g.*, screen the diversion at California Lake along the mainstem Sacramento River downstream from the confluence with Cottonwood Creek). For example, improving fish passage at Millville on Clover Creek in the Cow Creek watershed would open up 13 miles of spawning habitat for fall-run Chinook salmon and potentially spring-run Chinook salmon and steelhead. Fish passage could also be improved with a fish ladder at the Bassett diversion on Old Cow Creek.

G. Collaborate with the Corps to identify and remove riprap along reaches of nonnatal tributaries and the mainstem of the Sacramento River supporting salmonid spawning and/or rearing habitat (USFWS 2004b).

H. Restore habitat at inactive gravel mines and cease instream gravel mining (*e.g.*, Cottonwood Creek). Fill in the deep borrow pit in the Sacramento River at Turtle Bay created during the initial construction of Shasta Dam; this site continues to deplete spawning gravels downstream of Keswick Dam and hampers current gravel augmentation efforts.

I. Increase water use efficiency to a specified level (*e.g.*, irrigation efficiency in the ACID).

J. Ensure that Delta inflows for the Sacramento River and Yolo Bypass align with targets established in appropriate ongoing planning efforts and as provided in existing biological opinions.

IV. Potential Mitigation

The Service has tentatively identified the following measures as possible means for mitigation for SLWRI-associated impacts. Many of the following recommendations were also made by the Service in the May 2007 Planning Aid Memorandum for the SLWRI (USFWS 2007a).

A. Leave trees/shrubs in the Shasta Lake Inundation Zone for fish/wildlife habitat use (USFWS 2007a) and for western purple martin nesting habitat.

B. Conduct genetic analyses of Shasta huckleberry populations to determine if they are genetically distinct from the coastal red huckleberry populations. Protect other populations of Shasta huckleberry from disturbance through conservation easements or other means.

C. Conduct genetic analyses of the Shasta snow-wreath populations to determine what genetic diversity would be lost.

D. Survey for Shasta snow-wreath to determine the northern extent of its range and thus what percent of the total population and potential habitat would be affected by the SLWRI.

E. Transplant Shasta snow-wreath populations within the Inundation Zone to suitable protected habitat and monitor. Analyze the ability of Shasta snow-wreath to propagate upslope beyond the Inundation Zone. Remove invasive species (*e.g.*, Himalayan blackberry) that hinder the ability of Shasta snow-wreath to colonize new areas.

F. Protect other Shasta snow-wreath populations from disturbance in perpetuity through conservation easements or other means (*e.g.*, McCloud River arm between the bridge and the upstream reservoir).

G. Protect Cantelow’s lewisia populations from disturbance in perpetuity through conservation easements.

H. Protect Shasta sideband and Wintu sideband snails limestone outcrop habitats along the McCloud River and Pit River arms, respectively.

I. Protect Shasta chaparral snail and Shasta hesperian snail habitat from disturbance in perpetuity through conservation easements or other means.

J. Protect Shasta salamander habitat from disturbance in perpetuity through conservation easements or other means.

K. Collaborate with PG&E to manage flows in Shasta Lake tributaries for tributary stream habitat and flow enhancement (USFWS 2007a).

L. Remediate and restore mining sites and forest areas around and near Shasta Lake (*e.g.*, treat soils to reduce acidity, plant vegetation, clean up creeks, and eliminate acid mine drainage, etc.) (USFWS 2007a); however, remediation activities should not disturb Shasta huckleberry shrubs which are adapted to the low pH soils.

M. Restore Sacramento River riparian corridor habitat (*e.g.*, riparian, wetland, and other habitats, possibly at Sacramento River Conservation Area, and other sites). (USFWS 2007a).

N. Emphasize listed species recovery with project mitigation (consistent with CALFED ERP goals) (USFWS 2007a).

O. Implement a coarse sediment addition project that would sustain gravel and sand loads in the Sacramento River by adding sand and spawning-sized gravel on a regular basis and at a much larger scale to better mimic natural sediment loads and therefore provide the sediment from which the river would naturally create and maintain spawning riffles (USFWS 2007a).

P. Resolve the fish passage problems at the Red Bluff Diversion Dam so fish can take advantage of improvements downstream of the Shasta Dam and in Battle Creek, which is slated for instream habitat restoration (USFWS 2007a).

Q. Protect suitable limestone, mixed conifer, and conifer/woodland habitat for special-status bat species near Shasta Lake (*i.e.*, western red bat, spotted bat, Townsend’ big-eared bat, pallid bat, greater western mastiff bat, small-footed myotis, long-eared myotis, fringed myotis, long-legged myotis, and Yuma myotis).

    1. Use acoustic technology to identify bat species within the Inundation Zone that would be affected by the SLWRI.

    2. Collaborate with the California Bat Conservation Fund.

3. Create and/or enhance bat habitat by constructing bat boxes and modifying entrances to abandoned mine shafts in the lake area (*e.g.*, install bat gates to allow bat passage but block human access) (USFWS 2007a).

4. Restrict the use of pesticides in bat foraging areas.

R. Select oak woodland mitigation sites for protection based on the following criteria (CalPIF 2002a):

1. Sites with intact oak regeneration and decay processes.

2. Current indicators of avian population health.

3. Diverse age structure of oak trees, particularly large old oak trees.

4. Diverse range of oak woodland habitat types.

5. Suitable surrounding land use. For example, oak woodlands that are adjacent to pastures or residential developments may be more accessible to European starlings, which compete for nest cavities with other secondary cavity nesters (Verner *et al.* 1997, Merenlender *et al.* 1998). Urban or suburban development may also have a negative effect on the presence or abundance of some bird species, including lark sparrow and rufous-crowned sparrow, in adjacent oak woodlands (Stralberg and Williams 2002).

6. Adjacent to intact chaparral, grassland, pine, and/or riparian habitats.

7. Conservation threats and opportunities for protection.

8. Proximity to existing high quality sites.

9. Protect a diverse mosaic of oak woodland habitat as recommended in the "Conservation Measures and Habitat Protection for Focal Bird Species" section below.

S. Select coniferous forest mitigation sites for protection based on the following criteria:

1. Protect limestone outcrops supporting special-status species such as Shasta salamander, Shasta sideband, Wintu sideband snail, and Shasta snow-wreath.

2. Protect habitat supporting special-status species such as Pacific fisher, northern spotted owl, sharp-skinned hawk, Cooper's hawk, northern goshawk, peregrine falcon, flammulated owl, long-eared owl, black swift, Vaux's swift, Lewis's woodpecker, red-breasted sapsucker, olive-sided flycatcher, western purple martin, special-status bat species (listed above), and ringtail.

3. Protect existing old-growth/late-successional coniferous forest habitats.

4. Protect habitat with current indicators of avian population health.

5. Ensure that patch size, configuration, and connectivity of coniferous habitats adequately support the desired populations of coniferous forest associated species.

6. Select sites near existing high quality sites.

7. Select sites with intact adjacent habitats.

8. Select sites with suitable surrounding land use. Surrounding land uses may influence the population sizes of brown-headed cowbirds and predators such as domestic cats, jays, skunks, raccoons, ravens, and crows.

    a. Beneficial adjacent land uses include wilderness and unimproved parks/open space (provided substantial nonnative species problems do not exist) with suitable management.

    b. Detrimental adjacent land uses include manicured parks and golf courses, rural homes/ranchettes, permanent and intensive feedlots, and intensive urban/suburban developments.

9. High tree species diversity.

10. Large trees and large snags.

11. Diverse shrub understory and forest floor complexity (*e.g.*, downed logs, root wads and a deep litter layer).

12. Protect a diverse mosaic of coniferous forest habitat as recommended in the "Conservation Measures and Habitat Protection for Focal Bird Species" section below.

T. Select mixed chaparral mitigation sites for protection based on the following criteria (RHJV 2004):

1. Current indicators of avian population health.

2. Proximity to existing high quality sites.

3. Suitable surrounding land use. Surrounding land uses may influence the population sizes of brown-headed cowbirds and predators such as domestic cats, jays, skunks, raccoons, ravens, and crows.

4. Ensure that the patch size, configuration, and connectivity of restored scrub habitats adequately support the desired populations of scrub-dependent species.

5. Restore natural fire regimes in areas that still have potential to function within historic range of variability.

6. Protect a diverse mosaic of mixed chaparral habitat as recommended in the "Conservation Measures and Habitat Protection for Focal Bird Species" section below.

U. Select montane riparian mitigation sites for protection based on the following criteria (RHJV 2004):

1. Protect habitat supporting special-status species such as Shasta snow-wreath, western purple martin, foothill yellow-legged frog, tailed frog, northwestern pond turtle, osprey, bald eagle, willow flycatcher, bank swallow, yellow warbler, yellow-breasted chat, Shasta hesperian snail, pebblesnails and other aquatic mollusks.

2. See the "Suggested Modifications to CP4" section above for recommendations for restoring riparian habitat, maintaining wide corridors, and preserving areas with natural hydrologic processes intact.

3. Protect a diverse mosaic of montane riparian habitat as recommended in the "Conservation Measures and Habitat Protection for Focal Bird Species" section below.

V. Identify mitigation sites and strategies early in the planning process for final analysis and incorporation within the HEP application.

V. Conservation Measures and Habitat Protection for CalPIF Focal Bird Species

The Service recommends that Reclamation incorporate the following conservation measures and habitat protection priorities identified for focal bird species in the CalPIF and RHJV Bird Conservation Plans (CalPIF 2000, 2002a, 2002b, 2004, RHJV 2004) as mitigation for habitat loss around Shasta Lake.

A. Ponderosa Pine and Mixed Coniferous Forest

1. For flammulated owl, preserve snags and ensure snag recruitment in ponderosa pine forests and explore the use of nest boxes.

2. For brown creeper, protect large patch sizes of old-growth Douglas fir and mixed confer habitat with large snags and deeply-furrowed trees for foraging; buffer of at least 80 m from logging activities.

3. For black-throated gray warbler, protect dry slopes brushy understory beneath oak and coniferous trees, open conifer forests interspersed with shrubs or forest edges, or shrubby stands of trees.

4. For dark-eyed junco, protect moist coniferous forest edge with an herbaceous understory that remains green throughout the breeding season. Mechanical destruction of the herbaceous layer and intensive cattle grazing should be avoided during the breeding season (April through August).

5. For fox sparrow, protect mixed conifer forest with shrubby understory and restore the natural fire cycle through controlled burns.

6. For golden-crowned kinglet, protect breeding habitat in subalpine spruce or fir forests and mixed coniferous-deciduous forests with cool, moist, fairly closed canopy. Minimize forest thinning. Manage for stands of spruce or subalpine fir at least 150 years of age and with high canopy cover. Manage for forest diversity instead of pure stands of pine.

7. For MacGillivray's warbler, protect riparian, Douglas fir, redwoods, chaparral, and clearcut sites with mixed coniferous and deciduous trees that provide dense undergrowth with well-developed understories and moderate cover. Manage for shrubby seral habitats and avoid mechanical shrub removal. Reduce grazing pressure.

8. For olive-sided flycatcher, protect habitats with abundant high, open perches where late-seral stage forest and early-seral staged open-canopied habitat are juxtaposed. Manage with frequent, low intensity prescribed burns to decrease canopy; allow fires to burn and refrain from salvaging logging. Protect natural openings within old-growth forests with exposed rocks and south-facing slopes. Manage for a mosaic and diverse forest.

9. For pileated woodpecker, protect mature and old-growth dense coniferous forests, mixed forests, open woodland, or second growth habitats with an abundance of standing live, dead, or dying trees, snags, and stumps and a tall, closed canopy with large diameter trees. Retain logging residue and downed wood. Reduce habitat fragmentation.

10. For red-breasted nuthatch, protect mature to late-successional coniferous forests with the presence of old, diseased and dead trees. Mixed stands may include Douglas fir, white fir, spruce, hemlock, cedar or pine trees, and may involve a deciduous component as well. Manage for the presence of old, diseased, and dead trees. Maintain forest diversity including diseased and multi-aged trees.

11. For Vaux's swift, protect ponderosa pine, Douglas fir, and mixed-conifer forests with the presence of large hollow snags, snags with broken tops, or old pileated woodpecker cavities for breeding. Preserve snags and ensure snag recruitment through controlled burns.

12. For western tanager, preserve relatively open coniferous or mixed coniferous-deciduous forests. Manage for a diverse coniferous forest system.

B. Oak Woodland

1. For acorn woodpecker, maintain large tracts of land to include a natural diversity of oak species or intraspecific oak varieties with different seeding phenologies to help avoid synchronous or wide geographic-scale crop failures. Protect large tracts of oak woodlands away from disturbance. Maintain a similar high density of snags and dead

tree limbs, or soft-wooded live trees such as pines or sycamores (35 granary trees/100 ha, or 1 snag every 2.86 ha). Do not allow intensive grazing that limits the recruitment of new oaks.

2. For blue-gray gnatcatcher, protect open scrubby areas with diverse structure, including a mosaic of oaks and shrubs. Sites selected for protection should have beneficial adjacent land uses that minimize parasitism by brown-headed cowbird and predation by domestic cats, dogs, and raccoons. Beneficial adjacent land uses include wilderness areas, unimproved parks/open space provided substantial invasive species issues do not exist, grazed oak woodlands, and timber production forests. Detrimental adjacent land uses that promote brown-headed cowbird parasitism include urban/suburban development, rural homes/ranchettes, manicured parks and golf course, dairies, intensive feedlots, and active livestock grazing.

3. For lark sparrow, use controlled low-temperature burns to reduce the vegetative density of an area. Pesticide use should be restricted. Control invasive exotic grasses and restore with native plant species. Ground disturbance (*i.e.*, grazing, off-trail recreation, burning, and mowing) should be limited during the breeding season (March – August).

4. For western bluebird, protect sites with older trees with naturally occurring or previously excavated cavities.

5. For oak titmouse, protect areas of moderate canopy cover (40 – 70 percent) with natural cavities or holes previously excavated by woodpeckers.

6. For yellow-billed magpie, protect oak savanna, where large trees are found within large expanses of open ground; especially valley floors, gentle slopes and open park-like areas, including along stream courses or near a permanent water source.

C. Mixed Chaparral

1. For greater roadrunner, protect large areas with minimal human development that contain a mixture of shrub cover for nesting and open areas of low grasses for foraging and open habitat with minimal human development. Restrict pesticide use.

2. For wrentit, protect areas with mature, dense shrub habitats; work to minimize fragmentation, and incorporate corridors connecting habitat fragments.

3. For mountain quail, protect areas with an average distance to protective cover of 1.5 m, an average shrub cover of 46 percent, and availability of a permanent water source within 0.8 km (Winter 2002).

D. Montane Riparian

1. For black-headed grosbeak, protect small riparian corridors (less than 200 meters in length and 20 -50 meters in width) along forest edges with cottonwood-willow associations, vegetation diversity, vertical complexity, and blackberry or wild grape

for cover. Target old growth riparian forest, with large, shady oaks and cottonwoods, as well as in relatively open areas in early successional riparian zones and along levees. Pesticide use should be restricted.

2. For willow flycatcher, prioritize the protection and restoration of riparian deciduous shrub vegetation, particularly willow thickets, and address the problem of cowbird parasitism.

3. For common yellowthroat, protect marsh habitats with a riparian habitat corridor. Restrict livestock grazing and pesticide use. Minimize habitat disturbance from mid-April – September.

4. For song sparrow, protect early successional riparian habitat near marshy areas or running water with moderately dense vegetation, plenty of light, exposed ground or leaf litter for foraging, and plenty of blackberry and rushes for nesting. Stop channel incision (restore the water table) in places that a creek has incised.

5. For Swainson’s thrush, protect dense thickets (canopy closure 40-100 percent) near streams or wet meadows with abundant snags and 25-50 cm dbh live stems.

6. For tree swallow, protect areas with fresh water, marshlands, or open areas, usually near water, including fields, marshes, shorelines, and wooded swamps with standing dead trees with nest cavities for nesting and aerial foraging.

7. For yellow-breasted chat, protect dense early successional riparian thickets of willows with vine tangles of Himalayan blackberry, California wild rose, and pipevine and dense brush associated with streams, swampy ground and the borders of small ponds. Some taller trees (*i.e.*, cottonwoods and alders) are required for song perches. Minimize logging.

VI. Priorities for Project Benefits to Fish and Wildlife (USFWS 2007a)

A. Meeting the ERP milestones for recovery of Chinook salmon and steelhead (CALFED Phase I condition of Biological Opinions and NCCP Determination).

B. Meeting the ERP milestones to benefit covered fish species.

C. Meeting obligations for water supply under the EWA.

D. Creating secure storage for EWA assets.

E. Meet CVPIA AFRP flow standards (which are not always met on Sacramento River).

F. American River (meeting steelhead flow targets and other flow needs for lower American River and AFRP).

G. Meet Delta water quality requirements (Trinity River import reductions exacerbates this condition).

H. Provide for refuge water supplies for Level 2 and Level 4 water.

I. Provide for seasonal flow enhancements which could include flow releases that simulate natural seasonal flows and increased flows at various times of year to provide more suitable fish habitat and water temperatures. (See ERP proposed actions in Table D-1 of the Service's Programmatic Biological Opinion for CALFED).

VII. National Bald Eagle Management Guidelines (USFWS 2007b)

Minimize adverse affects to the bald eagle by incorporating the avoidance and minimization measures identified in the National Bald Eagle Management Guidelines (USFWS 2007b). Construction activities should be timed and spaced to minimize effects during the following critical bald eagle nesting periods: nest building (most sensitive phase) in January – mid-April; egg laying/incubation in February – May; hatchling/rearing young in March – July.

VIII. Invasive Species

Reclamation should analyze the effects of the SLWRI on the spread of invasive species and develop mitigation measures to minimize their spread. Below are recommendations for controlling the spread of the New Zealand mud snail (CDFG 2008a).

A. New Zealand Mud Snail

1. Have extra waders and boots for use in infested waters only. Store them separately.
2. After leaving the water inspect waders, boots, float tubes, boats and trailers, dogs and any gear used in the water.
3. Remove visible snails with a stiff brush and follow with a rinsing.
4. If possible, freeze or completely dry out wet gear before reuse.
5. Never transport live fish or other aquatic animals or plants from one body of water to another.

IX. Other Recommendations

Reclamation should incorporate the recommendations in Appendix C (pp. 23 – 25) of this report that the Service provided in the February 17, 2007, Planning Aid Memorandum for the SLWRI (USFWS 2007a). Reclamation should also incorporate the appropriate conservation measures for CALFED MSCS species identified in the CALFED Programmatic Final EIR/EIS (CALFED 2000a,b) which are summarized in Appendix D of this report.

X. Additional Data Required

More information is required related to the following before the Service can thoroughly evaluate the effects of the SLWRI on fish and wildlife resources. Data needed include:

A. Details on habitat disturbance associated with each of the SLWRI alternatives

1. Location of aggregate mining and staging areas

2. Relocation sites of campgrounds, roads, bridges, marinas, etc. beyond the Inundation Zone

B. Ecosystem restoration defined in CP5

C. Definition of the allocation and use of the increased water supply reliability in each of the SLWRI alternatives

D. Clarify whether and quantify the extent that the cold water pool (378,000 af) in CP4 would be used to augment flows to provide additional benefits for fish and wildlife species. Specify the authority for those augmented flows, and identify if those flows would be at the discretion of the Service, NOAA Fisheries, and CDFG.

E. Salmod modeling data

1. Analysis of assumptions and limitations.

2. Full sensitivity analysis of the variables in the model.

3. Analysis of alternatives considered but removed from further analysis (e.g., AFS-1, AFS-2, and AFS-3) with the recently revised version of Salmod.

4. Analysis of AFS-1, AFS-2, and AFS-3 with higher dam raises (i.e., 18 feet).

5. Analysis of effects of riparian restoration along the mainstem Sacramento River, the lower reaches of nonnatal tributaries, and further downstream (i.e., RBDD to Colusa) on survival rates of juvenile salmonids

F. CALSIM II or other hydrological modeling data

1. Analysis of the assumptions and limitations of CALSIM II.

2. Analysis of monthly flow data disaggregated into daily flows and how closely it simulates actual flood events on daily and weekly time steps.

3. Yolo and Sutter Bypasses daily flows---effects of reduced flood flows on hydroperiods.

4. Delta---analysis of the effects of the SLWRI alternatives on X2 location and inflow/export ratios as it relates to sensitive Delta aquatic species.

5. Sensitivity runs with and without NODOS (Sites Reservoir).

6. Evaluation of other proposed CALFED water storage projects.

7. Changes in the operation of other CVP/SWP dams and effects on temperature and flows downstream.

8. Analysis of the capability of improving temperature and flow conditions for anadromous fish in the Sacramento River without raising Shasta Dam.

    a. Modifications to the TCD

    b. Operational changes at Shasta Dam

    c. Riparian restoration associated with AFRP and SRCAF

G. Evaluate the effects of changes in the timing, frequency, and duration of flood flows in the Sacramento River with the SLWRI on the following species/habitats using the SacEFT (ESSA Technologies Ltd. 2006).

    1. Fremont cottonwood regeneration

    2. Green sturgeon

    3. Chinook salmon

    4. Steelhead

    5. Bank swallow

    6. Northwestern pond turtle

H. Evaluate the capabilities and benefits of riparian restoration opportunities along the Sacramento River and tributaries on fish and wildlife resources using the SacEFT (ESSA Technologies Ltd. 2006).

I. Evaluate the effects of the SLWRI on fluvial processes in the Sacramento River using the daily Physical River Process model of the Sacramento River that Reclamation-Denver is currently developing.

J. HEP data

    1. Provide data for each of the SLWRI alternatives on the acreage of each habitat type that would be lost within the Inundation Zone or disturbed by the relocation of campgrounds, marinas, roads, bridges, and other facilities.

    2. Identify candidate mitigation sites.

K. Mitigation

    1. Potential mitigation sites

    2. Avoidance and minimization measures

    3. Identify conservation measures.

L. USFS Survey and Manage Species (*e.g.*, Shasta snow-wreath, Shasta chaparral snail, Shasta hesperian snail, Shasta salamander) and CALFED MSCS species.

  1. Current distribution and population
  2. What percent of the population and habitat would be lost or disturbed?
  3. Habitat fragmentation
  4. Protection status and level of threats to other populations of the species
  5. Analysis of the effects of the SLWRI alternatives on CALFED MSCS species

M. Data on location of abandoned mines and analysis of the effects of inundation

N. Effects of climate change

O. Monitoring and adaptive management plan

P. Effects of the recent OCAP ruling on the SLWRI

Q. Growth-inducing effects from increased water supply reliability within the CVP-SWP water service areas

  1. Conversion of natural lands into agriculture or urban sprawl
  2. Conversion of agricultural lands into urban sprawl
  3. Changes in crop cultivation based on increased water supply reliability

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United States Department of the Interior

Fish and Wildlife Service

Draft Fish and Wildlife Coordination Act Report

for the

SHASTA LAKE WATER RESOURCES INVESTIGATION

APPENDICES

June 2008

APPENDIX A

SELECTED MAPS AND PLATES FROM THE SHASTA LAKE WATER RESOURCES INVESTIGATION PLAN FORMULATION REPORT U.S. BUREAU OF RECLAMATION

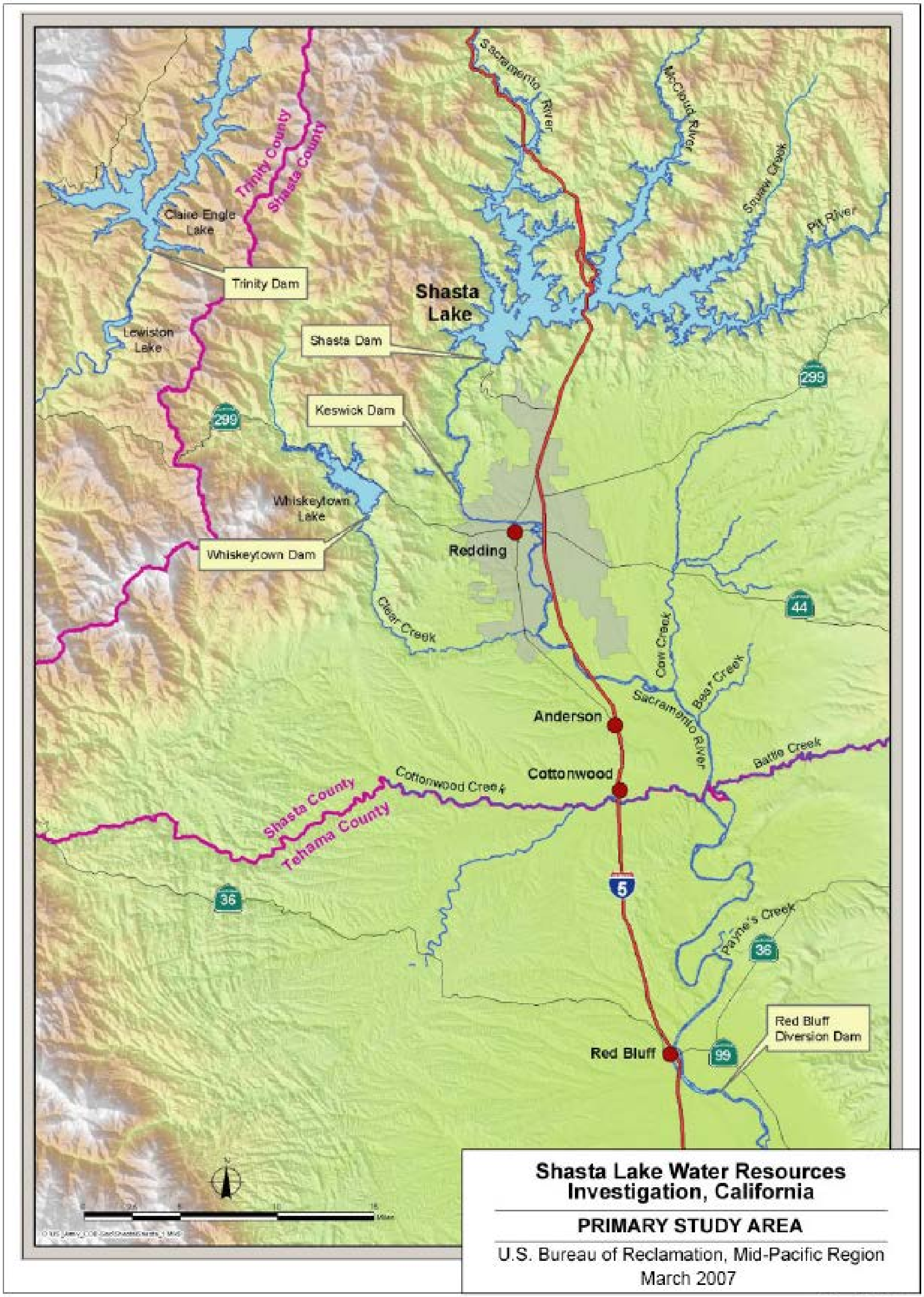
Trinity County
Shasta County
Claire Engle Lake
Trinity Dam
Lewiston Lake
Shasta Lake
Shasta Dam
Keswick Dam
Whiskeytown Lake
Whiskeytown Dam
Sacramento River
McCloud River
Squaw Creek
Pit River
299
Redding
44
Clear Creek
Cow Creek
Bear Creek
Anderson
Cottonwood
Cottonwood Creek
Battle Creek
Shasta County
Tehama County
36
5
Payne's Creek
Red Bluff
99
Red Bluff Diversion Dam
Shasta Lake Water Resources Investigation, California
PRIMARY STUDY AREA
U.S. Bureau of Reclamation, Mid-Pacific Region
March 2007

PLATE 1

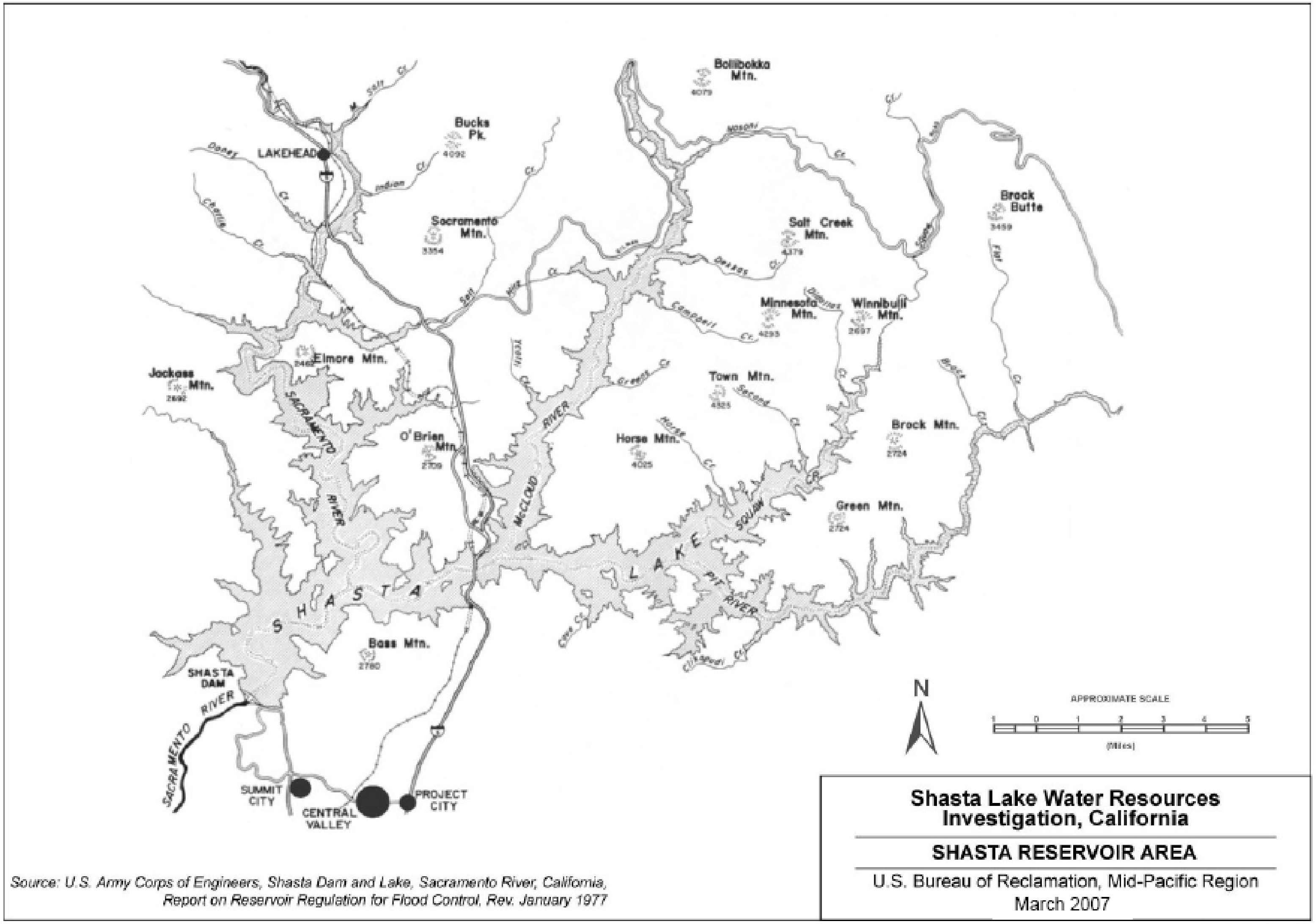
Bollibokka Mtn.
4079
Bucks Pk.
4092
LAKEHEAD
Sacramento Mtn.
3354
Salt Creek Mtn.
4379
Brock Butte
3459
Minnesota Mtn.
4295
Winnibulli Mtn.
2697
Elmore Mtn.
Jackass Mtn.
2692
Town Mtn.
4325
O'Brien Mtn.
2709
Horse Mtn.
4025
Brock Mtn.
2724
Green Mtn.
2724
Bass Mtn.
2780
SACRAMENTO RIVER
McCLOUD RIVER
SHASTA LAKE
SQUAW CR.
PIT RIVER
SHASTA DAM
SUMMIT CITY
CENTRAL VALLEY
PROJECT CITY
N
APPROXIMATE SCALE
(Miles)
Source: U.S. Army Corps of Engineers, Shasta Dam and Lake, Sacramento River, California, Report on Reservoir Regulation for Flood Control, Rev. January 1977
Shasta Lake Water Resources Investigation, California
SHASTA RESERVOIR AREA
U.S. Bureau of Reclamation, Mid-Pacific Region
March 2007

PLATE 2

Shasta Lake Water Resources Investigation, California

MAJOR CVP AND SWP FACILITIES

U.S. Bureau of Reclamation, Mid-Pacific Region
March 2007

PLATE 3

APPENDIX B

Salmod Modeling Results for the

Shasta Lake Water Resources Investigation

Sacramento Fish and Wildlife Office

U.S. Fish and Wildlife Service

SOURCES OF MORTALITY

<u>Salmod</u>

Salmod differentiates between "base" mortality and "project-related" mortality. Base, or background, rates of mortality cover all causes of death not otherwise modeled by Salmod. For example, "normal" or "background level" predation falls into this category, as would mortality due to chronically low dissolved oxygen egg survival, unscreened diversions, and the like. The fractional rates used came from the calibrated Trinity River model and are identical to those used previously on the Sacramento River (Bartholow, 2003). The weekly base mortality rates were eggs, 0.035; fry, 0.025; pre-smolts, 0.025; and immature smolts, 0.025. The adult rate was 0.002 based on judgment. "Project-related" mortality is simulated for each life stage of Chinook salmon in Salmod based on unsuitable water temperatures (temp mortality), flushing flows or redd dewatering (incubation), spawning on top of a currently incubating redd (superimposition), and forced movement due to flows and/or fish density (habitat mortality). Note that the No Action Alternative can have "Project-related" mortality (*i.e.*, temp, incubation, superimposition, and habitat) as defined above. Salmod also simulates mortality related to entrainment of salmonids in unscreened water diversions (seasonal mortality). The different types of mortality simulated by Salmod for each life stage are further defined below:

- <u>Pre-spawn base mortality</u>: number of eggs lost due to mortality of adult females before spawning due to factors that would occur regardless of the Project (*e.g.*, predation); pre-spawn base mortality is assigned a weekly mortality rate of 0.002
- <u>Pre-spawn project mortality</u>: number of eggs lost *in vivo* (while eggs are still inside the female) due to Project-related temperature mortality prior to spawning
- <u>Incubation mortality</u>: number of eggs lost due to flushing flows or redd dewatering resulting from Project-related actions (*i.e.*, above background levels)
- <u>Superimposition</u>: number of eggs lost due to spawning on top of a currently incubating redd resulting from Project-related activities
- <u>Eggs-base mortality</u>: number of eggs lost due to factors that would occur regardless of the Project; in Salmod the weekly eggs-base mortality rate is assigned a value of 0.035
- <u>Eggs-temp mortality</u>: number of eggs lost due to unsuitable water temperatures in which the exposure kills the egg after spawning
- <u>Fry-base mortality</u>: number of fry lost due to factors that would occur regardless of the Project (*e.g.*, predation); in Salmod the weekly fry-base mortality rate is assigned a value of 0.025
- <u>Fry-temp mortality:</u> number of fry lost due to unsuitable water temperatures
- <u>Fry-habitat mortality</u>: number of fry lost due to Project-related mortality resulting from forced movement due to habitat constraints; this mortality is triggered by flow and fish density within the habitat
- <u>Pre-smolt-base mortality</u>: number of pre-smolts lost due to factors that would occur regardless of the Project (*e.g.*, predation); in Salmod the weekly pre-smolt-base mortality rate is assigned a value of 0.025
- <u>Pre-smolt-temp mortality</u>: number of pre-smolts lost due to unsuitable water temperatures

- Pre-smolt-habitat mortality: number of pre-smolts lost due to Project-related mortality resulting from forced movement due to habitat constraints; this mortality is triggered by flow and fish density within the habitat
- Pre-smolt seasonal mortality: extra outmigration mortality due to factors such as water diversions
- Immature smolt-base mortality: number of immature smolts lost due to factors that would occur regardless of the Project (*e.g.*, predation); in Salmod the weekly immature smolt-base mortality rate is assigned a value of 0.025
- Immature smolt-temp mortality: number of immature smolts lost due to unsuitable water temperatures
- Immature smolt-habitat mortality: number of immature smolts lost due to Project-related mortality resulting from forced movement due to habitat constraints; this mortality is triggered by flow and fish density within the habitat
- Immature smolt-seasonal mortality: extra outmigration mortality due to factors such as water diversions

The sources of mortality for eggs, fry, pre-smolts, and immature smolts in No Action and the SLWRI alternatives are summarized below and in Figures B-1A – B-64E (pp. 89 – 346 at the end of this appendix) for each of the four runs of Chinook salmon. Changes in mortality rates and survival rates in the SLWRI alternatives relative to No Action were generally reported below for years in which the change was 2 percent or greater.

Winter-run Chinook Salmon

Egg Mortality

The survival rates and sources of mortality of winter-run Chinook salmon eggs using the 1999 – 2006 population average are illustrated in Figures B-1A-D and B-2A-E. The survival rates and sources of mortality of winter-run Chinook salmon eggs using the AFRP population goals are illustrated in Figures B-3A-D and B-4A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to the flushing or dewatering of redds (incubation mortality) was the greatest source of mortality for winter-run Chinook salmon eggs in the No Action Alternative during 90 percent of the years simulated (water years 1922 – 2002). The incubation mortality rate ranged from 0.0 – 9.3 percent with an average rate of 1.9 percent (median of 1.5 percent). Thermal mortality of eggs while in the redd (eggs-temp) was restricted to 8.6 percent of the years simulated (7 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) and 1 out of 17 dry water years (1932) when the eggs-temp mortality rate ranged from 4.2 – 55.6 percent. Pre-spawning thermal mortality and superimposition mortality were insignificant throughout the simulation period. The survival rate of winter-run eggs ranged from 52.8 – 60.6 percent during 94 percent of the years simulated (76 out of 81 years). The survival rate was reduced to 17.9 – 45.9 percent during 5 out of 13 critical water years due to eggs-temp mortality.

The number of winter-run eggs surviving exceeded 6.5 million during 94 percent of the years simulated.

Using the AFRP population goals, superimposition increased to be the second largest source of mortality of winter-run eggs in the No Action Alternative. Other than base mortality, superimposition was the greatest source of mortality for winter-run Chinook salmon eggs during 93 percent of the years simulated (water years 1922 – 2002). The superimposition mortality rate ranged from 6.4 – 30.5 percent with an average rate of 15.0 percent (median of 15.0 percent). The incubation mortality rate ranged from 0.0 – 9.1 percent with an average rate of 1.8 percent (median of 1.4 percent). Thermal mortality of eggs while in the redd (eggs-temp) was restricted to 8.6 percent of the years simulated (7 out of 81 years); this occurred during 6 out of 13 critical water years and 1 out of 17 dry water years when the eggs-temp mortality rate ranged from 4.2 – 55.6 percent. Pre-spawning thermal mortality was insignificant throughout the simulation period. The survival rate of winter-run eggs ranged from 40.2 – 52.5 percent during 93 percent of the years simulated (75 out of 81 years). The survival rate was reduced to 12.3 – 32.7 percent during 5 out of 13 critical water years due to eggs-temp mortality. In 1998 the survival rate of winter-run eggs was reduced to 37.7 percent due to a superimposition mortality rate of 30.5 percent. The number of winter-run eggs surviving exceeded 25 million during 94 percent of the years simulated.

CP1

Using the 1999 – 2006 population average, other than base mortality, incubation mortality was the greatest source of mortality for winter-run Chinook salmon eggs in CP1 during 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the incubation mortality rate in CP1 ranged from 0.0 – 9.3 percent with an average rate of 2.0 percent (median of 1.4 percent). Eggs-temp mortality in CP1, like in No Action, was restricted to 8.6 percent of the years simulated (7 out of 81 years) including 6 out of 13 critical water years and 1 out of 17 dry water years. CP1 reduced the eggs-temp mortality rate relative to No Action by 6.1 – 20.1 percent during 5 critical water years but increased eggs-temp mortality by 9.2 percent during the critical water year 1977. The eggs-temp mortality did not change relative to No Action during the dry water year 1932. Pre-spawning thermal mortality and superimposition mortality were insignificant throughout the simulation period as in No Action.

In summary, using the 1999 – 2006 population average, the survival rate of winter-run eggs in CP1 relative to No Action increased by 5.6 – 18.8 percent during 5 out of 13 critical water years due to a decrease in thermal mortality of eggs while in the redd. However, the benefit of the larger cold water pool in CP1 was observed in only 6 percent of the years during the 1923 – 2003 simulation period. During the critical water year 1977, the survival rate of winter-run eggs actually decreased by 8.0 percent in CP1 relative to No Action due to an increase in thermal mortality of eggs while in the redd. The average annual number of winter-run egg survivors increased by 43,573 in CP1 relative to No Action, but the median number of egg survivors *decreased* by 11,161.

Using the AFRP population goals, superimposition increased to be the second largest source of mortality of winter-run eggs in CP1 as in the No Action Alternative. The superimposition mortality rate did not change significantly relative to No Action (except during the wet year 1927 when the mortality rate decreased by 16.4 percent) and ranged from 6.4 – 30.6 percent with an average rate of 15.4 percent (compared to 15.0 percent in No Action). The incubation mortality rate, similar to No Action, ranged from 0.0 – 9.0 percent with an average rate of 1.9 percent (median of 1.7 percent). Eggs-temp mortality in CP1, like in No Action, was restricted to 8.6 percent of the years simulated (7 out of 81 years) including 6 out of 13 critical water years and 1 out of 17 dry water years. CP1 reduced the eggs-temp mortality rate relative to No Action by 5.2 – 15.6 percent during 5 critical water years but increased eggs-temp mortality by 8.0 percent during the critical water year 1977. The eggs-temp mortality did not change relative to No Action during the dry water year 1932. Pre-spawning thermal mortality was insignificant throughout the simulation period as in No Action.

In summary, using the AFRP population goals, the survival rate of winter-run eggs in CP1 relative to No Action increased by 3.2 – 14.1 percent during 5 out of 13 critical water years due to a decrease in thermal mortality of eggs while in the redd. However, the benefit of the larger cold water pool in CP1 was observed in only 6 percent of the years during the 1923 – 2003 simulation period. During the critical water year 1977, the survival rate of winter-run eggs actually decreased by 4.8 percent in CP1 relative to No Action due to an increase in thermal mortality of eggs while in the redd. The average annual number of winter-run egg survivors *decreased* by 16,378 in CP1 relative to No Action, and the median number of egg survivors *decreased* by 73,494.

CP2

Using the 1999 – 2006 population average, other than base mortality, incubation mortality was the greatest source of mortality for winter-run Chinook salmon eggs in CP2 during 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action and CP1, the incubation mortality rate in CP2 ranged from 0.0 – 9.3 percent with an average rate of 2.0 percent (median of 1.6 percent). Eggs-temp mortality in CP2, like in No Action and CP1, was restricted to 8.6 percent of the years simulated (7 out of 81 years) including 6 out of 13 critical water years and 1 out of 17 dry water years. CP2 reduced the eggs-temp mortality rate relative to No Action by 2.5 – 20.3 percent during 5 critical water years, but increased eggs-temp mortality by 6.8 percent during the critical water year 1977. The eggs-temp mortality did not change relative to No Action during the dry water year 1932. Pre-spawning thermal mortality and superimposition mortality were insignificant throughout the simulation period as in No Action and CP1.

In summary, using the 1999 – 2006 population average, the survival rate of winter-run eggs in CP2 relative to No Action increased by 2.6 – 19.0 percent during 5 out of 13 critical water years due to a decrease in thermal mortality of eggs while in the redd. However, the benefit of the larger cold water pool in CP2 was observed in only 6 percent of the years during the 1923 – 2003 simulation period. During the critical water year 1977, the survival rate of winter-run eggs actually decreased by 6.1 percent in CP1 relative to No Action due to an increase in thermal mortality of eggs while in the redd. The average annual number of winter-run egg survivors increased by 32,193 in CP2 relative to No Action, but the median number of egg survivors *decreased* by 18,758.

Using the AFRP population goals, superimposition increased to be the second largest source of mortality of winter-run eggs in CP2 as in the No Action Alternative and CP1. The average superimposition mortality rate increased slightly from 15.0 percent in No Action to 15.7 percent in CP2. The superimposition mortality rate in CP2 increased by 2.1 – 16.4 percent relative to No Action during 10 percent of the years simulated (8 out of 81 years). The incubation mortality rate, similar to No Action, ranged from 0.0 – 9.0 percent with an average rate of 1.9 percent (median of 1.6 percent). Eggs-temp mortality in CP2, like in No Action and CP1, was restricted to 8.6 percent of the years simulated (7 out of 81 years) including 6 out of 13 critical water years and 1 out of 17 dry water years. CP2 reduced the eggs-temp mortality rate relative to No Action by 1.9 – 15.8 percent during 5 critical water years but increased eggs-temp mortality by 8.2 percent during the critical water year 1977. The eggs-temp mortality rate did not change relative to No Action during the dry water year 1932. Pre-spawning thermal mortality was insignificant throughout the simulation period as in No Action.

In summary, using the AFRP population goals, the survival rate of winter-run eggs in CP2 relative to No Action increased by 2.0 – 14.3 percent during 5 out of 13 critical water years due to a decrease in thermal mortality of eggs while in the redd. However, the benefit of the larger cold water pool in CP2 was observed in only 6 percent of the years during the 1923 – 2003 simulation period. During the critical water year 1977, the survival rate of winter-run eggs actually decreased by 2.8 percent in CP2 relative to No Action due to an increase in thermal mortality of eggs while in the redd. During 10 percent of the years simulated (8 out of 81 years), the survival rate of winter-run eggs in CP2 actually decreased relative to No Action by 2.0 – 12.4 percent due to increasing mortality from superimposition. The average annual number of winter-run egg survivors *decreased* by 191,814 in CP2 relative to No Action, and the median number of egg survivors *decreased* by 172,823.

CP3 and CP5

Using the 1999 – 2006 population average, other than base mortality, incubation mortality was the greatest source of mortality for winter-run Chinook salmon eggs in CP3 and CP5 during 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action, CP1, and CP2, the incubation mortality rate in CP3 and CP5 ranged from 0.0 – 9.3 percent with an average rate of 2.0 percent (median of 1.7 percent). Eggs-temp mortality in CP3 and CP5, like in No Action, CP1, and CP2, was restricted to 8.6 percent of the years simulated (7 out of 81 years) including 6 out of 13 critical water years and 1 out of 17 dry water years. CP3 and CP5 reduced the eggs-temp mortality rate relative to No Action by 1.9 – 20.7 percent during 5 critical water years and 1 dry water year (*i.e.*, 1932). Unlike CP1 and CP2, there was no significant increase in eggs-temp mortality relative to No Action in CP3 and CP5 during any of the years simulated. The eggs-temp mortality rate did not change significantly in CP3 and CP5 relative to No Action during the critical water year 1977 (+0.8 percent). Pre-spawning thermal mortality and superimposition mortality were insignificant throughout the simulation period as in No Action, CP1, and CP2.

In summary, using the 1999 – 2006 population average, the survival rate of winter-run eggs in CP3 and CP5 relative to No Action increased by 1.5 – 19.3 percent during 5 out of 13 critical water years and 1 out of 17 dry water years due to a decrease in thermal mortality of eggs while in the redd. However, this benefit of the larger cold water pool in CP3 and CP5 was observed in only 7 percent of the years during the 1923 – 2003 simulation period. The average annual number of winter-run egg survivors increased by 38,658 in CP3 and CP5 relative to No Action, but the median number of egg survivors *decreased* by 40,504.

Using the AFRP population goals, superimposition increased to be the second largest source of mortality of winter-run eggs in CP3 and CP5 as in the No Action Alternative, CP1, and CP2. The average superimposition mortality rate increased slightly from 15.0 percent in No Action to 15.6 percent in CP3 and CP5. The superimposition mortality rate in CP3 and CP5 increased by 2.3 – 8.1 percent relative to No Action during 12 percent of the years simulated (10 out of 81 years). The incubation mortality rate, similar to No Action, ranged from 0.0 – 9.0 percent with an average rate of 1.9 percent (median of 1.7 percent). Eggs-temp mortality in CP3 and CP5, like in No Action, CP1, and CP2, was restricted to 8.6 percent of the years simulated (7 out of 81 years) including 6 out of 13 critical water years and 1 out of 17 dry water years. CP3 and CP5 reduced the eggs-temp mortality rate relative to No Action by 2.3 – 16.1 percent during 5 critical water years and by 1.6 percent during 1 dry water year but increased eggs-temp mortality by 4.4 percent during the critical water year 1977. Pre-spawning thermal mortality was insignificant throughout the simulation period as in No Action.

In summary, using the AFRP population goals, the survival rate of winter-run eggs in CP3 and CP5 relative to No Action increased by 2.2 – 14.6 percent during 5 out of 13 critical water years and by 1.2 percent during 1 out of 17 dry water years due to a decrease in thermal mortality of eggs while in the redd. However, this benefit of the larger cold water pool in CP3 and CP5 was observed in only 7 percent of the years during the 1923 – 2003 simulation period. During 12 percent of the years simulated (10 out of 81 years), the survival rate of winter-run eggs in CP3 and CP5 actually decreased relative to No Action by 2.1 – 5.9 percent due to increasing mortality from superimposition. The average annual number of winter-run egg survivors *decreased* by 125,664 in CP3 and CP5 relative to No Action, and the median number of egg survivors *decreased* by 252,530.

CP4

Using the 1999 – 2006 population average, other than base mortality, incubation mortality was the greatest source of mortality for winter-run Chinook salmon eggs in CP4 during 97 percent of the years simulated (water years 1922 – 2002). Similar to the other alternatives, the incubation mortality rate in CP4 ranged from 0.0 – 9.4 percent with an average rate of 2.0 percent (median of 1.6 percent). The larger cold water pool in CP4 resulted in a reduction in thermal mortality of eggs while in the redd (eggs-temp) to insignificant levels except during the critical water years 1934 and 1977 (eggs-temp mortality rates of 8.1 and 3.8 percent, respectively); water year 1934 was preceded by six consecutive years of drought. This is in comparison to the other alternatives which still showed significant eggs-temp mortality during 5 critical water years and 1 dry water year during the 1923 – 2003 simulation period. Pre-spawning thermal mortality and superimposition mortality were insignificant throughout the simulation period as in the other alternatives.

In summary, using the 1999 – 2006 population average, the survival rate of winter-run eggs in CP4 relative to No Action increased by 4.0 – 39.1 percent during 6 out of 13 critical water years and 1 out of 17 dry water years due to a decrease in thermal mortality of eggs while in the redd. However, this benefit of the larger cold water pool in CP4 was observed in only 9 percent of the years during the 1923 – 2003 simulation period. The average annual number of winter-run egg survivors increased by 192,969 in CP4 relative to No Action, but the median number of egg survivors *decreased* by 34,960.

Using the AFRP population goals, superimposition increased to be the second largest source of mortality of winter-run eggs in CP4 as in the other alternatives. The average superimposition mortality rate increased slightly from 15.0 percent in No Action to 15.4 percent in CP4. The superimposition mortality rate in CP4 increased by 2.2 – 16.4 percent relative to No Action during 6 percent of the years simulated (5 out of 81 years) but decreased by 2.0 – 6.9 percent during 4 percent of the years simulated (3 out of 81 year). The incubation mortality rate, similar to No Action, ranged from 0.0 – 9.0 percent with an average rate of 2.0 percent (median of 1.7 percent). The larger cold water pool in CP4 resulted in a reduction in thermal mortality of eggs while in the redd (eggs-temp) to insignificant levels except during the critical water years 1934 and 1977 (eggs-temp mortality rates of 7.7 and 3.3 percent, respectively); water year 1934 was preceded by six consecutive years of drought. This is in comparison to the other alternatives which still showed significant eggs-temp mortality during 5 critical water years and 1 dry water year during the 1923 – 2003 simulation period. Pre-spawning thermal mortality was insignificant throughout the simulation period as in No Action.

In summary, using the AFRP population goals, the survival rate of winter-run eggs in CP4 relative to No Action increased by 9.2 – 29.7 percent during 6 out of 13 critical water years and by 3.3 percent during 1 out of 17 dry water years due to a decrease in thermal mortality of eggs while in the redd. However, this benefit of the larger cold water pool in CP4 was observed in only 9 percent of the years during the 1923 – 2003 simulation period. During 6 percent of the years simulated (5 out of 81 years), the survival rate of winter-run eggs in CP4 actually decreased relative to No Action by 2.1 – 12.7 percent due to increasing mortality from superimposition. The average annual number of winter-run egg survivors increased by 608,720 in CP4 relative to No Action, but the median number of egg survivors *decreased* by 223,631.

Fry Mortality

The survival rates and sources of mortality of winter-run Chinook salmon fry using the 1999 – 2006 population average are illustrated in Figures B-5A-D and B-6A-E. The survival rates and sources of mortality of winter-run Chinook salmon fry using the AFRP population goals are illustrated in Figures B-A-D and B-8A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for winter-run Chinook salmon fry in the No Action Alternative during over 90 percent of the years simulated (water years 1922 – 2002). The mortality rate due to habitat constraints ranged from 0.5 – 16.5 percent with an average rate of 8.7 percent (median of 9.2 percent). Thermal mortality of fry was restricted to 8.6 percent of the years simulated (7 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) and 1 out of 17 dry water years (1932) when the thermal mortality rate ranged from 2.7 – 13.3 percent. The survival rate of winter-run fry ranged from 69.8 – 82.1 percent throughout the simulation period. The number of winter-run fry survivors ranged from 5 – 6 million during 90 percent of the years simulated (73 out of 81 years). The number of winter-run fry survivors dropped to 1.7 – 4.9 million during the remaining 10 percent of the years simulated primarily due to thermal mortality of winter-run eggs while in the redd and thermal mortality of winter-run fry.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for winter-run Chinook salmon fry in the No Action Alternative during 98 percent of the years simulated (water years 1922 – 2002). The mortality rate due to habitat constraints ranged from 9.1 – 46.8 percent with an average rate of 39.4 percent (median of 40.7 percent); the habitat mortality rate exceeded 30 percent during 96 percent of the years simulated (78 out of 81 years). Thermal mortality of fry was restricted to 8.6 percent of the years simulated (7 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) and 1 out of 17 dry water years (1932) when the thermal mortality rate ranged from 2.1 – 12.0 percent. The survival rate of winter-run fry ranged from 40.7 – 68.7 percent throughout the simulation period. The number of winter-run fry survivors ranged from 12.5 – 16.7 million during 93 percent of the years simulated (75 out of 81 years). The number of winter-run fry survivors dropped to 5.4 – 11.3 million during the remaining 7 percent of the years simulated primarily due to thermal mortality of winter-run eggs while in the redd during some critical water years.

CP1

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for winter-run Chinook salmon fry in CP1 during over 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to habitat constraints ranged from 0.4 – 16.1 percent with an average rate of 8.9 percent (median of 9.1 percent). The habitat mortality rate decreased by 2.1 – 4.5 percent in CP1 relative to No Action during 11 percent of the years simulated (9 out of 81 years). However, the habitat mortality rate increased by 2.3 – 9.7 percent during 10 percent of the years simulated (8 out of 81 years). Thermal mortality of fry (exceeding 2 percent) occurred in 7 percent of the years simulated in CP1 (6 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) when the thermal mortality rate ranged from 3.2 – 13.2 percent. The thermal mortality rate of fry in CP1 decreased by 2.0 – 6.5 percent relative to No Action during 5 out of 13 critical water years but increased by 4.7 percent during the critical water year 1934. Similar to No Action, the survival rate of winter-run fry ranged from 69.2 – 81.3 percent throughout the simulation period. The survival rate of winter-run fry increased by 2.0 – 6.8 percent in CP1 relative to No Action during less than 10 percent of the years simulated (8 out of 81 years); however, the survival rate decreased by 2.1 – 7.5 percent during 9 percent of the years simulated (7 out of 81 years).

In summary, using the 1999 – 2006 population average, CP1 resulted in little change in the average and median survival rates of winter-run Chinook salmon fry relative to No Action (average survival rate: CP1 = 75.8 percent, No Action = 75.9 percent; median survival rate CP1 = 75.6 percent, No Action = 75.8 percent). However, a significant decrease in the thermal mortality rate of winter-run eggs during 5 critical water years resulted in an increase in the total number of fry survivors by 333,000 – 1,490,000 during the same 5 critical waters years. The average annual number of winter-run fry survivors increased by 25,112 in CP1 relative to No Action, but the median number of fry survivors *decreased* by 3,728.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for winter-run Chinook salmon fry in CP1 during 99 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to habitat constraints ranged from 6.2 – 47.5 percent with an average rate of 39.1 percent (median of 39.8 percent). The habitat mortality rate decreased by 2.0 - 7.8 percent in CP1 relative to No Action during 20 percent of the years simulated (16 out of 81 years). However, the habitat mortality rate increased by 2.0 – 12.3 percent during 11 percent of the years simulated (9 out of 81 years). Thermal mortality of fry (exceeding 2 percent) occurred in 7 percent of the years simulated in CP1 (6 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) when the thermal mortality rate ranged from 2.3 – 12.2 percent. The thermal mortality rate of fry in CP1 decreased by 3.7 – 5.7 percent relative to No Action during 3 out of 13 critical water years but increased by 3.1 percent during the critical water year 1934. The survival rate of winter-run fry ranged from 41.3 – 74.6 percent in CP1 (compared to 40.7 – 68.7 percent in No Action) with an average survival rate of 47.9 percent (47.6 percent in No Action) and a median survival rate of 47.6 percent (46.7 percent in No Action).

In summary, using the AFRP population goals, the survival rate of winter-run fry increased by 2.0 – 8.4 percent in CP1 relative to No Action during 17 percent of the years simulated (14 out of 81 years); however, the survival rate decreased by 2.1 – 10.3 percent during 7 percent of the years simulated (6 out of 81 years). A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of fry survivors by 1,132,009 – 2,892,000 during the same 4 critical waters years. The average annual number of winter-run fry survivors increased by 94,895 in CP1 relative to No Action, and the median number of fry survivors increased by 103,439.

CP2

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for winter-run Chinook salmon fry in CP2 during over 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to habitat constraints ranged from 0.3 – 15.1 percent with an average rate of 8.8 percent (median of 9.1 percent). The habitat mortality rate decreased by 2.0 – 7.7 percent in CP2 relative to No Action during 10 percent of the years simulated (8 out of 81 years). However, the habitat mortality rate increased by 2.3 – 7.7 percent during 10 percent of the years simulated (8 out of 81 years). Thermal mortality of fry (exceeding 2 percent) occurred in 7 percent of the years simulated in CP2 (6 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) when the thermal mortality rate ranged from 3.2 – 13.2 percent. The thermal mortality rate of fry in CP2 decreased by 2.4 – 4.7 percent relative to No Action during 4 out of 13 critical water years but increased by 5.2 percent during the critical water year 1934. Similar to No Action, the survival rate of winter-run fry ranged from 69.1 – 81.7 percent throughout the simulation period. The survival rate of winter-run fry increased by 2.0 – 6.7 percent in CP2 relative to No Action during less than 10 percent of the years simulated (8 out of 81 years); however, the survival rate decreased by 2.0 – 5.5 percent during11 percent of the years simulated (9 out of 81 years).

In summary, using the 1999 – 2006 population average, CP2 resulted in little change in the average and median survival rates of winter-run Chinook salmon relative to No Action (average survival rate: CP2 = 75.7 percent, No Action = 75.9 percent; median survival rate CP2 = 75.3 percent, No Action = 75.8 percent). However, a significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of fry survivors by 321,000 – 1,534,000 during the same 4 critical waters years. The average annual number of winter-run fry survivors increased by 14,524 in CP2 relative to No Action, but the median number of fry survivors *decreased* by 31,169.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for winter-run Chinook salmon fry in CP2 during 99 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to habitat constraints ranged from 9.3 – 47.2 percent with an average rate of 38.7 percent (median of 39.0 percent). The habitat mortality rate decreased by 2.1 – 10.2 percent in CP2 relative to No Action during 27 percent of the years simulated (22 out of 81 years). However, the habitat mortality rate increased by 2.0 – 12.8 percent during 9 percent of the years simulated (7 out of 81 years). Thermal mortality of fry (exceeding 2 percent) occurred in 7 percent of the years simulated in CP2 (6 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) when the thermal mortality rate ranged from 2.3 – 12.5 percent. The thermal mortality rate of fry in CP2 decreased by 2.8 – 4.3 percent relative to No Action during 3 out of 13 critical water years but increased by 3.4 percent during the critical water year 1934. The survival rate of winter-run fry ranged from 41.2 – 70.4 percent in CP2 (compared to 40.7 – 68.7 percent in No Action) with an average survival rate of 48.2 percent (47.6 percent in No Action) and a median survival rate of 47.8 percent (46.7 percent in No Action).

In summary, using the AFRP population goals, the survival rate of winter-run fry increased by 2.0 – 8.8 percent in CP2 relative to No Action during 23 percent of the years simulated (19 out of

81 years); however, the survival rate decreased by 2.0 – 11.2 percent during 6 percent of the years simulated (5 out of 81 years). A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of fry survivors by 1,101,893 – 2,888,366 during the same 4 critical waters years. The average annual number of winter-run fry survivors increased by 104,998 in CP2 relative to No Action, and the median number of fry survivors increased by 19,732.

CP3 and CP5

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for winter-run Chinook salmon fry in CP3 and CP5 during over 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to habitat constraints ranged from 0.7 – 16.3 percent with an average rate of 8.7 percent (median of 9.1 percent). The habitat mortality rate decreased by 2.0 – 7.4 percent in CP3 and CP5 relative to No Action during 12 percent of the years simulated (10 out of 81 years). However, the habitat mortality rate increased by 2.1 – 7.6 percent during 12 percent of the years simulated (10 out of 81 years). Thermal mortality of fry (exceeding 2 percent) occurred in 7 percent of the years simulated in CP3 and CP5 (6 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) when the thermal mortality rate ranged from 2.4 – 12.1 percent. The thermal mortality rate of fry in CP3 and CP5 decreased by 2.9 – 6.0 percent relative to No Action during 4 out of 13 critical water years but increased by 3.6 percent during the critical water year 1934. Similar to No Action, the survival rate of winter-run fry ranged from 70.4 – 82.7 percent throughout the simulation period. The survival rate of winter-run fry increased by 2.1 – 6.4 percent in CP3 and CP5 relative to No Action during less than 11 percent of the years simulated (9 out of 81 years); however, the survival rate decreased by 2.2 – 5.0 percent during 12 percent of the years simulated (10 out of 81 years).

In summary, using the 1999 – 2006 population average, CP3 and CP5 resulted in little change in the average and median survival rates of winter-run Chinook salmon relative to No Action (average survival rate: CP3 and CP5 = 75.8 percent, No Action = 75.9 percent; median survival rate CP3 and CP5 = 75.2 percent, No Action = 75.8 percent). However, a significant decrease in the thermal mortality rate of winter-run eggs during 3 critical water years resulted in an increase in the total number of fry survivors by 893,000 - 1,576,000 during the same 3 critical waters years. The average annual number of winter-run fry survivors increased by 28,767 in CP3 and CP5 relative to No Action, but the median number of fry survivors *decreased* by 28,156.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for winter-run Chinook salmon fry in CP3 and CP5 throughout the simulation period (water years 1922 – 2002). Similar to No Action, the mortality rate due to habitat constraints ranged from 18.4 – 46.4 percent with an average rate of 38.9 percent (median of 38.9 percent). The habitat mortality rate decreased by 2.0 – 7.9 percent in CP3 and CP5 relative to No Action during 28 percent of the years simulated (23 out of 81 years). However, the habitat mortality rate increased by 2.1 – 11.8 percent during 9 percent of the years simulated (7 out of 81 years). Thermal mortality of fry (exceeding 2 percent) occurred in 6 percent of the years simulated in CP3 and CP5 (6 out of 81 years); this occurred during 5 out of 13 critical water years (1924, 1931, 1934, 1977, and 1992) when the thermal mortality rate ranged from 3.4 – 10.5 percent. The thermal mortality rate of fry in CP3 and CP5 decreased by 4.0 – 4.7 percent relative to No Action during 3 out of 13 critical water years but increased by 1.4 percent during the critical water year 1934. The survival rate of winter-run fry ranged from 41.8 – 61.6 percent in CP3 and CP5 (compared to 40.7 – 68.7 percent in No Action) with an average survival rate of 47.9 percent (47.6 percent in No Action) and a median survival rate of 47.9 percent (46.7 percent in No Action).

In summary, using the AFRP population goals, the survival rate of winter-run fry increased by 2.1 – 5.6 percent in CP3 and CP5 relative to No Action during 21 percent of the years simulated (17 out of 81 years); however, the survival rate decreased by 2.0 – 15.1 percent during 7 percent of the years simulated (6 out of 81 years). A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of fry survivors by 1,955,317 – 3,272,438 during the same 4 critical waters years. The average annual number of winter-run fry survivors increased by 107,680 in CP3 and CP5 relative to No Action, and the median number of fry survivors increased by 1,807.

CP4

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for winter-run Chinook salmon fry in CP4 throughout the simulation period (water years 1922 – 2002). Similar to No Action, the mortality rate due to habitat constraints ranged from 2.7 – 14.3 percent with an average rate of 8.6 percent (median of 8.8 percent). The habitat mortality rate decreased by 2.0 – 8.9 percent in CP4 relative to No Action during 19 percent of the years simulated (15 out of 81 years). However, the habitat mortality rate increased by 2.1 – 11.8 percent during 12 percent of the years simulated (10 out of 81 years). Due to the enlarged cold water pool in CP4, the thermal mortality rate of fry never exceeded 2 percent only during the critical water year 1934 following six consecutive years of drought. The thermal mortality rate of fry in CP4 decreased by 2.7 – 12.9 percent relative to No Action during 6 out of 13 critical water years and 1 out of 17 dry water years. Similar to No Action, the survival rate of winter-run fry in CP4 ranged from 69.8 – 82.1 percent throughout the simulation period. The survival rate of winter-run fry increased by 2.1 – 8.2 percent in CP4 relative to No Action during 14 percent of the years simulated (11 out of 81 years); however, the survival rate decreased by 2.0 – 6.6 percent during 16 percent of the years simulated (13 out of 81 years).

In summary, using the 1999 – 2006 population average, CP4 resulted in little change in the average and median survival rates of winter-run Chinook salmon relative to No Action (average survival rate: CP4 = 76.0 percent, No Action = 75.9 percent; median survival rate CP4 = 75.8 percent, No Action = 75.8 percent). However, a significant decrease in the thermal mortality rate of winter-run eggs during 5 critical water years resulted in an increase in the total number of fry survivors by 1,183,457 – 3,332,902 during the same 5 critical waters years. The average annual number of winter-run fry survivors increased by 154,232 in CP4 relative to No Action, but the median number of fry survivors *decreased* by 28,204.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for winter-run Chinook salmon fry in CP4 throughout the simulation period (water years 1922 – 2002). The mortality rate due to habitat constraints ranged from 31.6 – 46.5 percent with an average rate of 39.3 percent (median of 39.1 percent). The habitat mortality rate decreased by 2.1 – 8.3 percent in CP4 relative to No Action during 33 percent of the years simulated (27 out of 81 years). However, the habitat mortality rate increased by 2.6 – 31.4 percent during 11 percent of the years simulated (9 out of 81 years). The thermal mortality of fry never exceeded 1.8 percent in CP4. The thermal mortality rate of fry in CP4 decreased by 2.1 – 11.2 percent relative to No Action during 6 out of 13 critical water years and 1 out of 17 dry water years. The survival rate of winter-run fry ranged from 41.8 – 55.3 percent in CP4 (compared to 40.7 – 68.7 percent in No Action) with an average survival rate of 47.8 percent (47.6 percent in No Action) and a median survival rate of 47.6 percent (46.7 percent in No Action).

In summary, using the AFRP population goals, the survival rate of winter-run fry increased by 2.1 – 6.9 percent in CP4 relative to No Action during 28 percent of the years simulated (23 out of 81 years); however, the survival rate decreased by 2.4 – 21.8 percent during 10 percent of the years simulated (8 out of 81 years). A significant decrease in the thermal mortality rate of winter-run eggs during 6 critical water years resulted in an increase in the total number of fry survivors by 3,289,952 – 7,952,641during the same 6 critical waters years. The average annual number of winter-run fry survivors increased by 462,603 in CP4 relative to No Action, and the median number of fry survivors increased by 118,235.

Pre-smolt Mortality

The survival rates and sources of mortality of winter-run Chinook salmon pre-smolts using the 1999 – 2006 population average are illustrated in Figures B-9A-D and B-10A-E. The survival rates and sources of mortality of winter-run Chinook salmon pre-smolts using the AFRP population goals are illustrated in Figures B-11A-D and B-12A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for winter-run Chinook salmon pre-smolts in the No Action Alternative during over 90 percent of the years simulated (water years 1922 – 2002). The mortality rate due to entrainment in unscreened water diversions ranged from 0.6 – 6.1 percent with an average rate of 4.6 percent (median of 4.9 percent). Thermal mortality of pre-smolts was restricted to 8.6 percent of the years simulated (7 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) and 1 out of 17 dry water years (1932) when the thermal mortality rate ranged from 3.2 – 10.1 percent. The survival rate of winter-run pre-smolts ranged from 68.8 – 76.2 percent throughout the simulation period. The number of winter-run pre-smolt survivors ranged from 3.5 – 4.6 million during 91 percent of the years simulated (74 out of 81 years). The number of winter-run pre-smolt survivors dropped to 1.2 – 3.4 million during the remaining 9 percent of the years simulated primarily due to thermal mortality of winter-run eggs while in the redd.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for winter-run Chinook salmon pre-smolts in the No Action Alternative during over 90 percent of the years simulated (water years 1922 – 2002). The mortality rate due to entrainment in unscreened water diversions ranged from 0.9 – 6.3 percent with an average rate of 4.9 percent (median of 5.2 percent). Thermal mortality of pre-smolts was restricted to 8.6 percent of the years simulated (7 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) and 1 out of 17 dry water years (1932) when the thermal mortality rate ranged from 2.5 – 8.5 percent. The survival rate of winter-run pre-smolts ranged from 69.5 – 76.2 percent throughout the simulation period. The number of winter-run pre-smolt survivors ranged from 9.3 – 12.5 million during 93 percent of the years simulated (75 out of 81 years). The number of winter-run pre-smolt survivors dropped to 3.9 – 8.2 million during the remaining 7 percent of the years simulated primarily due to thermal mortality of winter-run eggs while in the redd.

CP1

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for winter-run Chinook salmon pre-smolts in CP1 during over 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.7 – 6.1 percent with an average rate of 4.7 percent (median of 5.1 percent). Like in No Action, the thermal mortality of pre-smolts (exceeding 2 percent) occurred in 7 percent of the years simulated in CP1 (6 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) when the thermal mortality rate ranged from 3.5 – 7.8 percent. The thermal mortality rate of pre-smolts in CP1 decreased by 4.4 percent relative to No Action during the critical water year 1934 following six consecutive years of drought but increased by 2.4 percent during the critical water year 1977. Similar to No Action, the survival rate of winter-run pre-smolts ranged from 70.0 – 76.2 percent throughout the simulation period.

In summary, using the 1999 – 2006 population average, CP1 resulted in little change in the average and median survival rates of winter-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP1 = 73.8 percent, No Action = 73.9 percent; median survival rate CP1 = 73.6 percent, No Action = 73.8 percent). The survival rate of winter-run pre-smolts increased by 4.1 percent during the critical water year 1934 but decreased by 2.0 percent during the critical water year 1924. A significant decrease in the thermal mortality rate of winter-run eggs during 5 critical water years resulted in an increase in the total number of pre-smolt survivors by 208,247 – 989,360 during the same 5 critical waters years. However, the number of pre-smolt survivors decreased by 271,589 and 491,194 in CP1 relative to No Action during the dry water year 1932 and the critical water year 1977, respectively. The average annual number of winter-run pre-smolt survivors increased by 10,787 in CP1 relative to No Action, but the median number of pre-smolt survivors *decreased* by 14,668.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for winter-run Chinook salmon pre-smolts in CP1 during over 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.9 – 6.4 percent with an average rate of 5.0 percent (median of 5.3 percent). Like in No Action, the thermal mortality of pre-smolts (exceeding 2 percent) occurred in 7 percent of the years simulated in CP1 (6 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) when the thermal mortality rate ranged from 2.5 – 7.1 percent. The thermal mortality rate of pre-smolts in CP1 decreased by 3.6 percent relative to No Action during the critical water year 1934 following six consecutive years of drought but increased by 2.5 percent during the critical water year 1977. Similar to No Action, the survival rate of winter-run pre-smolts ranged from 70.8 – 76.2 percent throughout the simulation period.

In summary, using the AFRP population goals, CP1 resulted in little change in the average and median survival rates of winter-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP1 = 74.6 percent, No Action = 74.7 percent; median survival rate CP1 = 74.7 percent, No Action = 74.8 percent). The survival rate of winter-run pre-smolts increased by 3.1 percent in CP1 relative to No Action during the critical water year 1934. A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of pre-smolt survivors by 1,034,635 – 1,931,527 during the same 4 critical waters years. However, the number of pre-smolt survivors decreased by 1,268,495 and 1,460,294 in CP1 relative to No Action during the wet water year 1927 and the critical water year 1977, respectively. The average annual number of winter-run pre-smolt survivors increased by 56,498 in CP1 relative to No Action, and the median number of pre-smolt survivors increased by 62,927.

CP2

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for winter-run Chinook salmon pre-smolts in CP2 during over 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.7 – 6.2 percent with an average rate of 4.8 percent (median of 5.2 percent). Like in No Action, the thermal mortality of pre-smolts (exceeding 2 percent) occurred in 7 percent of the years simulated in CP2 (6 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) when the thermal mortality rate ranged from 3.1 – 7.8 percent. The thermal mortality rate of pre-smolts in CP2 decreased by 4.1 percent relative to No Action during the critical water year 1934 following six consecutive years of drought but increased by 1.2 – 1.4 percent during the critical water years 1924 and 1977.

Similar to No Action, the survival rate of winter-run pre-smolts ranged from 70.0 – 76.3 percent throughout the simulation period.

In summary, using the 1999 – 2006 population average, CP2 resulted in little change in the average and median survival rates of winter-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP2 = 73.7 percent, No Action = 73.9 percent; median survival rate CP2 = 73.6 percent, No Action = 73.8 percent). The survival rate of winter-run pre-smolts increased by 3.8 percent during the critical water year 1934 but decreased by 2.1 percent during the critical water year 1924. A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of pre-smolt survivors by 300,631 – 1,014,427 during the same 4 critical waters years. However, the number of pre-smolt survivors decreased by 363,284 in CP2 relative to No Action during the critical water year 1977. The average annual number of winter-run pre-smolt survivors *decreased* by 2,636 in CP2 relative to No Action, and the median number of pre-smolt survivors *decreased* by 35,217.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for winter-run Chinook salmon pre-smolts in CP2 during over 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 1.0 – 6.4 percent with an average rate of 5.1 percent (median of 5.4 percent). Like in No Action, the thermal mortality of pre-smolts (exceeding 2 percent) occurred in 7 percent of the years simulated in CP2 (6 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) when the thermal mortality rate ranged from 2.4 – 6.2 percent. The thermal mortality rate of pre-smolts in CP2 decreased by 3.2 percent relative to No Action during the critical water year 1934 following six consecutive years of drought but increased by 1.6 percent during the critical water year 1977. Similar to No Action, the survival rate of winter-run pre-smolts ranged from 71.1 – 76.2 percent throughout the simulation period.

In summary, using the AFRP population goals, CP2 resulted in little change in the average and median survival rates of winter-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP2 = 74.5 percent, No Action = 74.7 percent; median survival rate CP2 = 74.6 percent, No Action = 74.8 percent). The survival rate of winter-run pre-smolts increased by 2.7 percent in CP2 relative to No Action during the critical water year 1934. A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of pre-smolt survivors by 979,091 – 1,931,527 during the same 4 critical waters years. However, the number of pre-smolt survivors decreased by 725,608 – 1,213,951 in CP2 relative to No Action during the wet water years 1927 and 1952 and the critical water year 1977. The average annual number of winter-run pre-smolt survivors increased by 52,003 in CP2 relative to No Action, but the median number of pre-smolt survivors *decreased* by 32,438.

CP3 and CP5

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for winter-run Chinook salmon pre-smolts in CP3 and CP5 during over 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.8 – 6.4 percent with an average rate of 4.9 percent (median of 5.2 percent). Like in No Action, the thermal mortality of pre-smolts (exceeding 2 percent) occurred in 7 percent of the years simulated in CP3 and CP5 (6 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) when the thermal mortality rate ranged from 2.6 – 6.9 percent. The thermal mortality rate of pre-smolts in CP3 and CP5 decreased by 2.6 – 4.9 percent relative to No Action during the critical water years 1931, 1933, and 1934. Similar to No Action, the survival rate of winter-run pre-smolts ranged from 70.5 – 76.2 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP3 and CP5 resulted in little change in the average and median survival rates of winter-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP3 and CP5 = 73.6 percent, No Action = 73.9 percent; median survival rate CP3 and CP5 = 73.4 percent, No Action = 73.8 percent). The survival rate of winter-run pre-smolts increased by 4.3 percent during the critical water year 1934. A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of pre-smolt survivors by 512,108 – 1,060,710 during the same 4 critical waters years. The average annual number of winter-run pre-smolt survivors increased by 2,587 in CP3 and CP5 relative to No Action, but the median number of pre-smolt survivors *decreased* by 36,806.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for winter-run Chinook salmon pre-smolts in CP3 and CP5 during over 90 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 1.3 – 6.6 percent with an average rate of 5.2 percent (median of 5.4 percent). Like in No Action, the thermal mortality of pre-smolts (exceeding 2 percent) occurred in 7 percent of the years simulated in CP3 and CP5 (6 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) when the thermal mortality rate ranged from 2.0 – 5.4 percent. The thermal mortality rate of pre-smolts in CP3 and CP5 decreased by 1.9 – 3.9 percent relative to No Action during the critical water years 1931, 1933, and 1934. Similar to No Action, the survival rate of winter-run pre-smolts ranged from 71.1 – 76.1 percent throughout the simulation period.

In summary, using the AFRP population goals, CP3 and CP5 resulted in little change in the average and median survival rates of winter-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP3 and CP5 = 74.5 percent, No Action = 74.7 percent; median survival rate CP3 and CP5 = 74.5 percent, No Action = 74.8 percent). The survival rate of winter-run pre-smolts increased by 2.3 - 3.1 percent in CP3 and CP5 relative to No Action during the critical water years 1931 and 1934. A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of pre-smolt survivors by 1,625,216 – 2,229,244 during the same 4 critical waters years. The average annual number of winter-run pre-smolt survivors increased by 46,111 in CP3 and CP5 relative to No Action, but the median number of pre-smolt survivors *decreased* by 38,032.

CP4

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for winter-run Chinook salmon pre-smolts in CP4 during 98 percent of the years simulated (water years 1922 – 2002). The mortality rate due to entrainment in unscreened water diversions increased slightly in CP4 relative to No Action and ranged from 1.8 – 6.4 percent with an average rate of 5.1 percent (median of 5.3 percent). This increase in mortality of pre-smolts in CP4 due to unscreened water diversions was likely due to a decrease in the thermal mortality of pre-smolts during some critical water years relative to No Action. The thermal mortality rate of pre-smolts in CP4 never exceeded 1.7 percent compared to No Action and the other alternatives when thermal mortality rates exceeded 2 percent during 6 out of 13 critical water years representing 7 percent of the simulation period (6 out of 81 years). Thus the enlarged cold water pool in CP4 was successful in reducing thermal mortality of pre-smolts to insignificant levels (less than 2 percent). The survival rate of winter-run pre-smolts in CP4 ranged from 72.2 – 77.2 percent throughout the simulation period. However, CP4 resulted in little change in the average and median survival rates of winter-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP4 = 73.6 percent, No Action = 73.9 percent; median survival rate CP4 = 73.3 percent, No Action = 73.8 percent).

In summary, using the 1999 - 2006 population average, the survival rate of winter-run pre-smolts in CP4 relative to No Action increased by 2.0 – 7.1 percent during 5 out of 13 critical water years and 1 out of 17 dry water years during the simulation period. The average change in the number of pre-smolt survivors in CP4 relative to No Action was 95,470 while the median change was -52,754. Due to a significant reduction in the thermal mortality of winter-run eggs, fry, and pre-smolts during six critical water years, the number of pre-smolt survivors increased by 1,011,612 – 2,738,835 during those same six critical water years. The average annual number of winter-run pre-smolt survivors increased by 95,470 in CP4 relative to No Action, but the median number of pre-smolt survivors *decreased* by 52,754.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for winter-run Chinook salmon pre-smolts in CP4 during 100 percent of the years simulated (water years 1922 – 2002). The mortality rate due to entrainment in unscreened water diversions increased slightly in CP4 relative to No Action and ranged from 2.4 – 6.6 percent with an average rate of 5.3 percent (median of 5.3 percent). This increase in mortality of pre-smolts in CP4 due to unscreened water diversions was likely due to a decrease in the thermal mortality of pre-smolts during some critical water years relative to No Action. The thermal mortality rate of pre-smolts in CP4 never exceeded 1.5 percent compared to No Action and the other alternatives when thermal mortality rates exceeded 2 percent during 6 out of 13 critical water years representing 7 percent of the simulation period (6 out of 81 years).

In summary, using the AFRP population goals, the enlarged cold water pool in CP4 was successful in reducing thermal mortality of pre-smolts to insignificant levels (less than 2 percent). The survival rate of winter-run pre-smolts in CP4 ranged from 73.5 – 76.8 percent throughout the simulation period. However, CP4 resulted in little change in the average and median survival rates of winter-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP4 = 74.5 percent, No Action = 74.7 percent; median survival rate CP4 = 74.5 percent, No Action = 74.8 percent). The survival rate of winter-run pre-smolts in CP4 relative to No Action increased by 2.3 – 6.5 percent during 4 out of 13 critical water years during the simulation period. The average change in the number of pre-smolt survivors in CP4 relative to No Action was 309,804 while the median change was -28.894. Due to a significant reduction in the thermal mortality of winter-run eggs, fry, and pre-smolts during six critical water year and one dry water year, the number of pre-smolt survivors increased by 2,203,006 – 6,139,203 during those same years. However, the number of pre-smolt survivors decreased in CP4 relative to No Action by 947,636 – 1,628,835 during two wet water years. The average annual number of winter-run pre-smolt survivors increased by 309,804 in CP4 relative to No Action, but the median number of pre-smolt survivors *decreased* by 28,894.

Immature Smolt Mortality

The survival rates and sources of mortality of winter-run Chinook salmon immature smolts using the 1999 – 2006 population average are illustrated in Figures B-13A-B and B-14A-E. The survival rates and sources of mortality of winter-run Chinook salmon immature smolts using the AFRP population goals are illustrated in Figures B-15A-B and B-16A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for winter-run Chinook salmon immature smolts in the No Action Alternative. The mortality rate due to entrainment in unscreened water diversions ranged from 0.1 – 3.6 percent with an average rate of 0.9 percent (median of 0.7 percent). The survival rate of winter-run immature smolts ranged from 86.0– 99.9 percent throughout the simulation period. The average survival rate was 97.4 percent and the median survival rate was 98.2 percent. The number of winter-run immature smolt survivors ranged from 3.5 – 4.3 million during 93 percent of the years simulated (75 out of 81 years). The number of winter-run pre-smolt survivors dropped to 1.0 – 3.1 million during the remaining 7 percent of the years simulated primarily due to thermal mortality of winter-run eggs while in the redd. Due to the restriction of the modeling to areas upstream of the Red Bluff Diversion Dam, Salmod likely overestimates the number immature smolt survivors in No Action and the other alternatives.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for winter-run

Chinook salmon immature smolts in the No Action Alternative. The mortality rate due to entrainment in unscreened water diversions ranged from 0.1 – 3.3 percent with an average rate of 0.7 percent (median of 0.5 percent). The survival rate of winter-run immature smolts ranged from 87.5– 99.9 percent throughout the simulation period. The average survival rate was 98.0 percent and the median survival rate was 98.6 percent. The number of winter-run immature smolt survivors ranged from 9.3 – 12.2 million during 93 percent of the years simulated (75 out of 81 years). The number of winter-run pre-smolt survivors dropped to 3.6 – 7.6 million during the remaining 7 percent of the years simulated primarily due to thermal mortality of winter-run eggs while in the redd.

CP1

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for winter-run Chinook salmon immature smolts in CP1 as in No Action. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.0 – 3.6 percent with an average rate of 0.8 percent (median of 0.6 percent). Similar to No Action, the survival rate of winter-run immature smolts ranged from 86.0 – 100.0 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP1 resulted in little change in the average and median survival rates of winter-run Chinook salmon immature smolts relative to No Action (average survival rate: CP1 = 97.6 percent, No Action = 97.4 percent; median survival rate CP1 = 98.6 percent, No Action = 98.2 percent). The survival rate of winter-run immature smolts increased by 2.1 percent during the critical water year 1924 but decreased by 1.6 percent during the critical water year 1977. A significant decrease in the thermal mortality rate of winter-run eggs during 5 critical water years resulted in an increase in the total number of immature smolt survivors by 216,355 – 965,678 during the same 5 critical waters years. However, the number of immature smolt survivors decreased by 258,467 and 445,826 in CP1 relative to No Action during the dry water year 1932 and the critical water year 1977, respectively. The average annual number of winter-run immature smolt survivors increased by 17,609 in CP1 relative to No Action, but the median number of immature smolt survivors *decreased* by 4,940.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for winter-run Chinook salmon immature smolts in CP1 as in No Action. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.0 – 3.4 percent with an average rate of 0.6 percent (median of 0.5 percent). Similar to No Action, the survival rate of winter-run immature smolts ranged from 87.3 – 99.9 percent throughout the simulation period.

In summary, using the AFRP population goals, CP1 resulted in little change in the average and median survival rates of winter-run Chinook salmon immature smolts relative to No Action (average survival rate: CP1 = 98.1 percent, No Action = 97.4 percent; median survival rate CP1

= 98.7 percent, No Action = 98.2 percent). The survival rate of winter-run immature smolts increased by 1.8 percent during the critical water year 1924 but decreased by 2.6 percent during the critical water year 1977. A significant decrease in the thermal mortality rate of winter-run eggs during 5 critical water years resulted in an increase in the total number of immature smolt survivors by 930,312– 1,957,147 during the same 5 critical waters years. However, the number of immature smolt survivors decreased by 1,210,553 and 1,456,597 in CP1 relative to No Action during the critical water year 1977 and the wet water year 1927, respectively. The average annual number of winter-run immature smolt survivors increased by 68,306 in CP1 relative to No Action, and the median number of immature smolt survivors increased by 73,498.

CP2

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for winter-run Chinook salmon immature smolts in CP2 as in No Action and the other alternatives. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.0 – 3.6 percent with an average rate of 0.8 percent (median of 0.5 percent). Similar to No Action, the survival rate of winter-run immature smolts ranged from 86.0 – 100.0 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP2 resulted in little change in the average and median survival rates of winter-run Chinook salmon immature smolts relative to No Action (average survival rate: CP2 = 97.7 percent, No Action = 97.4 percent; median survival rate CP2 = 98.7 percent, No Action = 98.2 percent). The survival rate of winter-run immature smolts increased by 2.5 percent during the critical water year 1924 but decreased by 1.4 percent during the critical water year 1977. A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of immature smolt survivors by 265,077 – 1,002,787 during the same 4 critical waters years. However, the number of immature smolt survivors decreased by 332,805 in CP2 relative to No Action during the critical water year 1977. The average annual number of winter-run immature smolt survivors increased by 9,980 in CP2 relative to No Action, but the median number of immature smolt survivors *decreased* by 23,685.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for winter-run Chinook salmon immature smolts in CP2 as in No Action. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.0 – 3.3 percent with an average rate of 0.6 percent (median of 0.4 percent). Similar to No Action, the survival rate of winter-run immature smolts ranged from 87.6 – 100.0 percent throughout the simulation period.

In summary, using the AFRP population goals, CP2 resulted in little change in the average and median survival rates of winter-run Chinook salmon immature smolts relative to No Action (average survival rate: CP2 = 98.2 percent, No Action = 97.4 percent; median survival rate CP2 = 98.9 percent, No Action = 98.2 percent). The survival rate of winter-run immature smolts increased by 1.7 percent during the critical water year 1924 but decreased by 2.3 percent during the critical water year 1977. A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of immature smolt survivors by 886,516 – 1,959,051 during the same 4 critical waters years. However, the number of immature smolt survivors decreased by 725,941 – 1,202,613 in CP2 relative to No Action during the critical water year 1977 and the wet water years 1927 and 1952. The average annual number of winter-run immature smolt survivors increased by 74,889 in CP2 relative to No Action, and the median number of immature smolt survivors increased by 24,040.

CP3 and CP5

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for winter-run Chinook salmon immature smolts in CP3 and CP5 as in No Action and the other alternatives. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.0 – 3.5 percent with an average rate of 0.7 percent (median of 0.5 percent). Similar to No Action, the survival rate of winter-run immature smolts ranged from 86.6 – 100.0 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP3 and CP5 resulted in little change in the average and median survival rates of winter-run Chinook salmon immature smolts relative to No Action (average survival rate: CP3 and CP5 = 97.9 percent, No Action = 97.4 percent; median survival rate CP3 and CP5 = 98.9 percent, No Action = 98.2 percent). The survival rate of winter-run immature smolts increased by 2.4 percent during the critical water year 1924 but decreased by 1.0 percent during the critical water year 1977. A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of immature smolt survivors by 478,869 – 1,040,627 during the same 4 critical waters years. However, the number of immature smolt survivors decreased by 154,002 – 159,618 in CP3 and CP5 relative to No Action during the critical water year 2001, the wet water year 1975, and the below normal water year 1979. The average annual number of winter-run immature smolt survivors increased by 19,141 in CP3 and CP5 relative to No Action, but the median number of immature smolt survivors *decreased* by 16,923.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for winter-run Chinook salmon immature smolts in CP3 and CP5 as in No Action. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.0 – 3.0 percent with an average rate of 0.6 percent (median of 0.4 percent). Similar to No Action, the survival rate of winter-run immature smolts ranged from 88.8 – 100.0 percent throughout the simulation period.

In summary, using the AFRP population goals, CP3 and CP5 resulted in little change in the average and median survival rates of winter-run Chinook salmon immature smolts relative to No Action (average survival rate: CP3 and CP5 = 98.3 percent, No Action = 97.4 percent; median survival rate CP3 and CP5 = 99.1 percent, No Action = 98.2 percent). The survival rate of winter-run immature smolts increased by 1.8 percent during the critical water year 1924 but decreased by 1.1 percent during the critical water year 1977. A significant decrease in the thermal mortality rate of winter-run eggs during 4 critical water years resulted in an increase in the total number of immature smolt survivors by 1,592,042 – 2,246,795 during the same 4 critical waters years. However, the number of immature smolt survivors decreased by 677,845 – 836,493 in CP3 and CP5 relative to No Action during the critical water year 1994 and the wet water year 1974. The average annual number of winter-run immature smolt survivors increased by 78,950 in CP3 and CP5 relative to No Action, but the median number of immature smolt survivors *decreased* by 3,954.

CP4

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for winter-run Chinook salmon immature smolts in CP4 as in No Action and the other alternatives. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.0 – 2.8 percent with an average rate of 0.6 percent (median of 0.4 percent). The survival rate of winter-run immature smolts ranged from 89.7 – 100.0 percent throughout the simulation period in CP4 compared to 86.0 – 99.9 percent in No Action.

In summary, using the 1999 - 2006 population goals, CP4 resulted in a slight increase in the average and median survival rates of winter-run Chinook salmon immature smolts relative to No Action (average survival rate: CP4 = 98.3 percent, No Action = 97.4 percent; median survival rate CP4 = 99.0 percent, No Action = 98.2 percent). The survival rate of winter-run immature smolts increased by 2.0 – 3.7 percent in CP4 relative to No Action during the critical water years 1924, 1931, 1934, and 1977 and the dry water year 1925. A significant decrease in the thermal mortality rate of winter-run eggs during 6 critical water years resulted in an increase in the total number of immature smolt survivors by 948,211 – 2,549,384 during those same six years. The average annual number of winter-run immature smolt survivors increased by 117,630 in CP4 relative to No Action, but the median number of immature smolt survivors *decreased* by 24,811.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for winter-run Chinook salmon immature smolts in CP4 as in No Action and the other alternatives. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.0 – 2.2 percent with an average rate of 0.5 percent (median of 0.3 percent). The survival rate of winter-run immature smolts ranged from 92.1 – 100.0 percent throughout the simulation period in CP4 compared to 86.0 – 99.9 percent in No Action.

In summary, using the AFRP population goals, CP4 resulted in a slight increase in the average and median survival rates of winter-run Chinook salmon immature smolts relative to No Action (average survival rate: CP4 = 98.7 percent, No Action = 97.4 percent; median survival rate CP4 = 99.2 percent, No Action = 98.2 percent). The survival rate of winter-run immature smolts increased by 2.4 – 4.5 percent in CP4 relative to No Action during the critical water years 1924, 1934, and 1977. A significant decrease in the thermal mortality rate of winter-run eggs during 6 critical water years and 1 dry water year resulted in an increase in the total number of immature smolt survivors by 2,262,821 – 5,937,015 during those same seven years. However, the number of immature smolt survivors decreased by 1,592,684 in CP4 relative to No Action during the wet water year 1927. The average annual number of winter-run immature smolt survivors increased by 357,169 in CP4 relative to No Action, and the median number of immature smolt survivors increased by 47,791.

Spring-run Chinook Salmon

Egg Mortality

The survival rates and sources of mortality of spring-run Chinook salmon eggs using the 1999 – 2006 population average are illustrated in Figures B-17A-D and B-18A-E. The survival rates and sources of mortality of spring-run Chinook salmon eggs using the AFRP population goals are illustrated in Figures B-19A-D and B-20A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), thermal mortality of eggs while in the redd (eggs-temp) was the major source of mortality of spring-run Chinook salmon eggs in the No Action Alternative. Significant (greater than 2 percent) eggs-temp mortality occurred during 38 percent of the years simulated (31 out of 81 years); the mortality rate was as high as 90 percent. Thermal mortality of eggs pre-spawning (pre-spawn project) was restricted to 8.6 percent of the years simulated (7 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) and 1 out of 17 dry water years (1932) when the eggs-temp mortality rate ranged from 3.9 – 50.7 percent. The incubation mortality rate (mortality due to the flushing or dewatering of redds) ranged from 0.0 – 6.1 percent with an average rate of 0.5 percent (median of 0.1 percent). Significant (greater than 2 percent) incubation mortality was limited to 6 percent of the years simulated (5 out of 81 years). Superimposition mortality was insignificant throughout the simulation period due to the extremely low numbers of spring-run simulated. However, Salmod likely underestimates superimposition mortality of spring-run eggs due to the model's inability to simulate competition for spawning sites between spring-run and fall-run Chinook salmon. The survival rate of spring-run eggs ranged from 45.3 – 64.2 percent during 91 percent of the years simulated (74 out of 81 years). The survival rate was reduced to 0.4 – 3.0 percent during 6 out of 13 critical water years and 1 out of 17 dry water years due to thermal mortality of eggs pre-spawning and while in the redd. The number of spring-run eggs surviving exceeded 224,000 during 91 percent of the years simulated.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), thermal mortality of eggs while in the redd (eggs-temp) was the major source of mortality of spring-run Chinook salmon eggs in the No Action Alternative. Significant (greater than 2 percent) eggs-temp mortality occurred during 41 percent of the years simulated (33 out of 81 years); the mortality rate was as high as 91 percent. Thermal mortality of eggs pre-spawning (pre-spawn project) was restricted to 8.6 percent of the years simulated (7 out of 81 years); this occurred during 6 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) and 1 out of 17 dry water years (1932) when the eggs-temp mortality rate ranged from 3.5 – 50.7 percent. The incubation mortality rate (mortality due to the flushing or dewatering of redds) ranged from 0.0 – 4.5 percent with an average rate of 0.4 percent (median of 0.1 percent). Significant (greater than 2 percent) incubation mortality was limited to 4 percent of the years simulated (3 out of 81 years). Superimposition mortality was insignificant throughout the simulation period (never exceeded

0.5 percent). However, Salmod likely underestimates superimposition mortality of spring-run eggs due to the model's inability to simulate competition for spawning sites between spring-run and fall-run Chinook salmon. The survival rate of spring-run eggs ranged from 44.5 – 64.0 percent during 91 percent of the years simulated (74 out of 81 years). The survival rate was reduced to 0.3 – 3.0 percent during 6 out of 13 critical water years and 1 out of 17 dry water years due to thermal mortality of eggs pre-spawning and while in the redd. The number of spring-run eggs surviving exceeded 23.6 million during 91 percent of the years simulated.

CP1

Using the 1999 – 2006 population average, the enlarged cold water pool in CP1 resulted in a decrease in the thermal mortality of spring-run eggs pre-spawning relative to No Action by 3.9 – 22.4 percent during 5 critical water years (*e.g.,* 1924, 1931, 1933, 1977, and 1992). However, the benefit of a decrease in thermal mortality of spring-run eggs pre-spawning was offset by a similar increase in thermal mortality of eggs while in the redd by 2.0 – 19.4 percent during those same 5 critical water years. The critical water year 1934, following six consecutive years of drought, showed the opposite trend with a 20.8 percent increase in the thermal mortality of eggs pre-spawning offset by a 20.1 percent decrease in thermal mortality of eggs while in the redd. Thermal mortality of eggs while in the redd in CP1 also decreased by 2.1 – 5.1 percent relative to No Action during 4 years during the 1923 – 2003 simulation period without a corresponding increase in the thermal mortality of eggs pre-spawning (*e.g.*, the dry water years 1925 and 1926, the below normal water year 1959, and the wet water year 1984). However, the thermal mortality rate of eggs while in the redd in CP1 increased by 6.9 and 3.0 percent relative to No Action during the critical water years 1994 and 2001, respectively. Egg mortality due to the flushing or dewatering of eggs (incubation mortality) in CP1 was similar to No Action ranging from 0.0 – 6.1 percent with an average of 0.5 percent (median 0.1 percent). Superimposition continued to be an insignificant source of mortality; however, as stated previously, the model likely underestimates superimposition mortality of spring-run eggs due to the inability to simulate competition with fall-run for spawning sites.

In summary, using the 1999 – 2006 population average, CP1 resulted in a significant (greater than 2 percent) increase in the survival rate of spring-run eggs relative to No Action by 3.4 and 2.3 percent during the dry water years 1925 and 1926, respectively, but a significant decrease in the survival rate by 4.8 and 2.2 percent during the critical water years 1994 and 2001, respectively. Overall, CP1 resulted in a 0.4 percent *decrease* in the average annual (and median) survival rate of spring-run Chinook salmon eggs relative to No Action during the 1923 – 2003 simulation period. The average annual number of spring-run egg survivors *decreased* by 1,867 in CP1 relative to No Action, and the median number of egg survivors *decreased* by 2,154.

Using the AFRP population goals, the enlarged cold water pool in CP1 resulted in a decrease in the thermal mortality of spring-run eggs pre-spawning relative to No Action by 3.9 – 23.7 percent during 5 critical water years (*e.g.*, 1924, 1931, 1933, 1977, and 1992). However, the benefit of a decrease in thermal mortality of spring-run eggs pre-spawning was offset by a similar increase in thermal mortality of eggs while in the redd by 1.9 – 22.4 percent during those same 5 critical water years. The critical water year 1934, following six consecutive years of drought, showed the opposite trend with a 23.8 percent increase in the thermal mortality of eggs pre-spawning offset by a 23.1 percent decrease in thermal mortality of eggs while in the redd. Thermal mortality of eggs while in the redd in CP1 also decreased by 2.0 – 5.2 percent relative to No Action during 6 years during the 1923 – 2003 simulation period without a corresponding increase in the thermal mortality of eggs pre-spawning (*e.g.*, the dry water years 1925 and 1926, the below normal water year 1959, and the wet water years 1984 and 1986, and the above normal water year 2000). However, the thermal mortality rate of eggs while in the redd in CP1 increased by 7.0 and 3.1 percent relative to No Action during the critical water years 1994 and 2001, respectively. Egg mortality due to the flushing or dewatering of eggs (incubation mortality) in CP1 was similar to No Action ranging from 0.0 – 4.9 percent with an average of 0.4 percent (median 0.1 percent). Superimposition continued to be an insignificant source of mortality (never exceeded 0.5 percent); however, as stated previously, the model likely underestimates superimposition mortality of spring-run eggs due to the inability to simulate competition with fall-run for spawning sites.

In summary, using the AFRP population goals, CP1 resulted in a significant (greater than 2 percent) increase in the survival rate of spring-run eggs relative to No Action by 3.4 and 2.4 percent during the dry water years 1925 and 1926, respectively, but a significant decrease in the survival rate by 2.0, 5.0, and 2.2 percent during the wet water year 1969 and the critical water years 1994 and 2001, respectively. Overall, CP1 resulted in a 0.4 percent *decrease* in the average annual (and median) survival rate of spring-run Chinook salmon eggs relative to No Action during the 1923 – 2003 simulation period. The average annual number of spring-run egg survivors *decreased* by 205,090 in CP1 relative to No Action, and the median number of egg survivors *decreased* by 237,167.

CP2

Using the 1999 – 2006 population average, the enlarged cold water pool in CP2 resulted in a decrease in the thermal mortality of spring-run eggs pre-spawning relative to No Action by 1.7 – 23.0 percent during 5 critical water years (*e.g.,* 1924, 1931, 1933, 1977, and 1992). However, the benefit of a decrease in thermal mortality of spring-run eggs pre-spawning was offset by a similar increase in thermal mortality of eggs while in the redd by 0.8 – 19.8 percent during those same 5 critical water years. The critical water year 1934, following six consecutive years of drought, showed the opposite trend with a 22.6 percent increase in the thermal mortality of eggs pre-spawning offset by a 21.5 percent decrease in thermal mortality of eggs while in the redd. Thermal mortality of eggs while in the redd in CP2 also decreased by 2.0 – 12.7 percent relative to No Action during 9 years during the 1923 – 2003 simulation period without a corresponding increase in the thermal mortality of eggs pre-spawning (*e.g.*, the critical water years 1988, 1991, and 1994; the dry water years 1925, 1926, and 1947; the below normal water year 1959; the above normal water year 2000; and the wet water years 1984). However, the thermal mortality rate of eggs while in the redd in CP2 increased by 2.0 percent relative to No Action during the dry water year 1981. Egg mortality due to the flushing or dewatering of eggs (incubation mortality) in CP2 was similar to No Action ranging from 0.0 – 6.5 percent with an average of 0.5 percent (median 0.1 percent). Superimposition continued to be an insignificant source of mortality; however, as stated previously, the model likely underestimates superimposition mortality of spring-run eggs due to the inability to simulate competition with fall-run for spawning sites.

In summary, using the 1999 – 2006 population average, CP2 resulted in a significant (greater than 2 percent) increase in the survival rate of spring-run eggs relative to No Action by 2.3 – 8.0 percent during 5 years over the 1923 – 2003 simulation period (*e.g.*, critical water years 1988 and 1994; dry water years 1925 and 1926; and below normal water year 1959) but a significant decrease in the survival rate by 2.2 – 2.4 percent during 4 years (*e.g.*, below normal water year 1923; above normal water years 1978 and 1993; and wet water year 1969). Overall, CP2 resulted in a 0.4 percent *decrease* in the average annual survival rate (0.6 percent *decrease* in the median annual survival rate) of spring-run Chinook salmon eggs relative to No Action during the 1923 – 2003 simulation period. The average annual number of spring-run egg survivors *decreased* by 1,796 in CP2 relative to No Action, and the median number of egg survivors *decreased* by 3,116.

Using the AFRP population goals, the enlarged cold water pool in CP2 resulted in a decrease in the thermal mortality of spring-run eggs pre-spawning relative to No Action by 1.6 – 24.2 percent during 5 critical water years (*e.g.*, 1924, 1931, 1933, 1977, and 1992). However, the benefit of a decrease in thermal mortality of spring-run eggs pre-spawning was offset by a similar increase in thermal mortality of eggs while in the redd by 0.8 – 22.7 percent during those same 5 critical water years. The critical water year 1934, following six consecutive years of drought, showed the opposite trend with a 25.8 percent increase in the thermal mortality of eggs pre-spawning offset by a 24.81 percent decrease in thermal mortality of eggs while in the redd. Thermal mortality of eggs while in the redd in CP2 also decreased by 2.1 – 13.1 percent relative to No Action during 10 years during the 1923 – 2003 simulation period without a corresponding increase in the thermal mortality of eggs pre-spawning (*e.g.*, the critical water years 1988, 1991, and 1994; the dry water years 1925, 1926, and 1947; the below normal water year 1959; the above normal water year 2000; and the wet water years 1984 and 1986). However, the thermal mortality rate of eggs while in the redd in CP2 increased by 2.1 percent relative to No Action during the dry water year 1981. Egg mortality due to the flushing or dewatering of eggs (incubation mortality) in CP2 was similar to No Action ranging from 0.0 – 5.2 percent with an average of 0.4 percent (median 0.1 percent). Superimposition continued to be an insignificant source of mortality; however, as stated previously, the model likely underestimates superimposition mortality of spring-run eggs due to the inability to simulate competition with fall-run for spawning sites.

In summary, using the AFRP population goals, CP2 resulted in a significant (greater than 2 percent) increase in the survival rate of spring-run eggs relative to No Action by 2.2 – 8.3 percent during 5 years over the 1923 – 2003 simulation period (*e.g.*, critical water years 1988 and 1994; dry water years 1925 and 1926; and below normal water year 1959) but a significant decrease in the survival rate by 2.1 – 2.7 percent during 3 years (below normal water year 1923; above normal water year 1978; and wet water year 1969). Overall, CP2 resulted in a 0.4 percent *decrease* in the average annual survival rate (0.6 percent *decrease* in the median annual survival rate) of spring-run Chinook salmon eggs relative to No Action during the 1923 – 2003 simulation period. The average annual number of spring-run egg survivors *decreased* by 187,362 in CP2 relative to No Action, and the median number of egg survivors *decreased* by 334,041.

CP3 and CP5

Using the 1999 – 2006 population average, the enlarged cold water pool in CP3 and CP5 resulted in a decrease in the thermal mortality of spring-run eggs pre-spawning relative to No Action by 2.0 – 27.3 percent during 5 critical water years (*e.g.,* 1924, 1931, 1933, 1977, and 1992). However, the benefit of a decrease in thermal mortality of spring-run eggs pre-spawning was offset by a similar increase in thermal mortality of eggs while in the redd by 1.3 – 24.6 percent during those same 5 critical water years. The critical water year 1934, following six consecutive years of drought, showed the opposite trend with a 14.7 percent increase in the thermal mortality of eggs pre-spawning offset by a 14.3 percent decrease in thermal mortality of eggs while in the redd. Thermal mortality of eggs while in the redd in CP3 and CP5 also decreased by 2.1 – 13.1 percent relative to No Action during 13 years during the 1923 – 2003 simulation period without a corresponding increase in the thermal mortality of eggs pre-spawning (*e.g.,* the critical water years 1988, 1991, 1994, and 2001; the dry water years 1925, 1926, 1947, and 1987; the below normal water year 1935 and 1959; the above normal water year 2000; and the wet water years 1984 and 1986). Egg mortality due to the flushing or dewatering of eggs (incubation mortality) in CP3 and CP5 was similar to No Action ranging from 0.0 – 8.4 percent with an average of 0.5 percent (median 0.1 percent). Superimposition continued to be an insignificant source of mortality; however, as stated previously, the model likely underestimates superimposition mortality of spring-run eggs due to the inability to simulate competition with fall-run for spawning sites.

In summary, using the 1999 – 2006 population average, CP3 and CP5 resulted in a significant (greater than 2 percent) increase in the survival rate of spring-run eggs relative to No Action by 2.0 – 8.2 percent during 8 years over the 1923 – 2003 simulation period (*e.g.*, critical water years 1988, 1991, and 1994; dry water years 1925 and 1926; below normal water years 1935 and 1959; and above normal water year 2000) but a significant *decrease* in the survival rate by 2.0 – 5.2 percent during 19 years (*e.g.*, 1 dry water year, 4 below normal water years, 4 above normal water years, and 10 wet water years). Overall, CP3 and CP5 resulted in a 0.6 percent *decrease* in the average annual survival rate (1.2 percent *decrease* in the median annual survival rate) of spring-run Chinook salmon eggs relative to No Action during the 1923 – 2003 simulation period. The average annual number of spring-run egg survivors *decreased* by 3,026 in CP3 and CP5 relative to No Action, and the median number of egg survivors *decreased* by 5,891.

Using the AFRP population goals, the enlarged cold water pool in CP3 and CP5 resulted in a decrease in the thermal mortality of spring-run eggs pre-spawning relative to No Action by 2.0 – 25.5 percent during 5 critical water years (*e.g.,* 1924, 1931, 1933, 1977, and 1992). However, the benefit of a decrease in thermal mortality of spring-run eggs pre-spawning was offset by a similar increase in thermal mortality of eggs while in the redd by 1.3 – 23.5 percent during those same 5 critical water years. The critical water year 1934, following six consecutive years of drought, showed the opposite trend with a 17.5 percent increase in the thermal mortality of eggs pre-spawning offset by a 17.1 percent decrease in thermal mortality of eggs while in the redd. Thermal mortality of eggs while in the redd in CP3 and CP5 also decreased by 2.2 – 13.4 percent relative to No Action during 13 years during the 1923 – 2003 simulation period without a corresponding increase in the thermal mortality of eggs pre-spawning (*e.g.,* the critical water years 1988, 1991, 1994, and 2001; the dry water years 1925, 1926, 1947, and 1987; the below normal water years 1935 and 1959; the above normal water year 2000; and the wet water years 1984 and 1986). However, the thermal mortality rate of eggs while in the redd in CP3 and CP5 increased by 2.0 percent relative to No Action during the dry water year 1981. Egg mortality due to the flushing or dewatering of eggs (incubation mortality) in CP3 and CP5 was similar to No Action ranging from 0.0 – 7.3 percent with an average of 0.4 percent (median 0.1 percent). Superimposition continued to be an insignificant source of mortality; however, as stated previously, the model likely underestimates superimposition mortality of spring-run eggs due to the inability to simulate competition with fall-run for spawning sites.

In summary, using the AFRP population goals, CP3 and CP5 resulted in a significant (greater than 2 percent) increase in the survival rate of spring-run eggs relative to No Action by 2.0 – 8.5 percent during 9 years over the 1923 – 2003 simulation period (*e.g.*, critical water years 1988, 1991, and 1994; dry water years 1925 and 1926; below normal water years 1935 and 1959; above normal water year 2000; and wet water year 1986) but a significant *decrease* in the survival rate by 2.0 – 5.8 percent during 20 years (*e.g.*, 2 dry water years, 4 below normal water years, 3 above normal water years, and 11 wet water years). Overall, CP3 and CP5 resulted in a 0.6 percent *decrease* in the average annual survival rate (1.2 percent *decrease* in the median annual survival rate) of spring-run Chinook salmon eggs relative to No Action during the 1923 – 2003 simulation period. The average annual number of spring-run egg survivors *decreased* by 309,310 in CP3 and CP5 relative to No Action, and the median number of egg survivors *decreased* by 634,756.

CP4

Using the 1999 – 2006 population average, the enlarged cold water pool in CP4 resulted in a decrease in the thermal mortality of spring-run eggs pre-spawning relative to No Action by 3.9 – 48.9 percent during 6 critical water years (*e.g.,* 1924, 1931, 1933, 1934, 1977, and 1992) and the dry water year 1932. However, the benefit of a decrease in thermal mortality of spring-run eggs pre-spawning was partly offset by an increase in thermal mortality of eggs while in the redd by 15.7 – 29.8 percent during the critical water years 1931, 1934, and 1977. Thermal mortality of eggs while in the redd in CP4 also decreased by 2.1 – 82.3 percent relative to No Action during 21 years during the 1923 – 2003 simulation period without a corresponding increase in the thermal mortality of eggs pre-spawning (*e.g.*, 9 critical water years, 6 dry water years, 3 below normal water years, 1 above normal water year, and 2 wet water years). Egg mortality due to the flushing or dewatering of eggs (incubation mortality) in CP4 was similar to No Action ranging from 0.0 – 8.8 percent with an average of 0.7 percent (median 0.2 percent). Superimposition continued to be an insignificant source of mortality; however, as stated previously, the model likely underestimates superimposition mortality of spring-run eggs due to the inability to simulate competition with fall-run for spawning sites.

In summary, using the 1999 – 2006 population average, CP4 resulted in a significant (greater than 2 percent) increase in the survival rate of spring-run eggs relative to No Action by 2.1 – 57.8 percent during 16 years over the 1923 – 2003 simulation period (*e.g.*, 9 critical water years, 4 dry water years, 2 below normal water years, and 1 above normal water year) but a significant *decrease* in the survival rate by 2.0 – 6.3 percent during 31 years (*e.g.*, 7 dry water years, 5 below normal water years, 4 above normal water years, and 15 wet water years). Overall, CP4 resulted in a 1.4 percent *increase* in the average annual survival rate but a 1.4 percent *decrease* in the median annual survival rate of spring-run Chinook salmon eggs relative to No Action during the 1923 – 2003 simulation period. The average annual number of spring-run egg survivors increased by 6,880 in CP4 relative to No Action, but the median number of egg survivors *decreased* by 6,691.

Using the AFRP population goals, the enlarged cold water pool in CP4 resulted in a decrease in the thermal mortality of spring-run eggs pre-spawning relative to No Action by 3.5 – 49.1 percent during 6 critical water years (*e.g.*, 1924, 1931, 1933, 1934, 1977, and 1992) and the dry water year 1932. However, the benefit of a decrease in thermal mortality of spring-run eggs pre-spawning was partly offset by an increase in thermal mortality of eggs while in the redd by 16.6 – 31.3 percent during the critical water years 1931, 1934, and 1977. Thermal mortality of eggs while in the redd in CP4 also decreased by 2.0 – 81.5 percent relative to No Action during 22 years during the 1923 – 2003 simulation period without a corresponding increase in the thermal mortality of eggs pre-spawning (*e.g.*, 9 critical water years, 7 dry water years, 3 below normal water years, 1 above normal water year, and 2 wet water years). Egg mortality due to the flushing or dewatering of eggs (incubation mortality) in CP4 was similar to No Action ranging from 0.0 – 8.0 percent with an average of 0.6 percent (median 0.2 percent). Superimposition continued to be an insignificant source of mortality; however, as stated previously, the model likely underestimates superimposition mortality of spring-run eggs due to the inability to simulate competition with fall-run for spawning sites.

In summary, using the AFRP population goals, CP4 resulted in a significant (greater than 2 percent) increase in the survival rate of spring-run eggs relative to No Action by 2.0 – 56.8 percent during 17 years over the 1923 – 2003 simulation period (*e.g.*, 10 critical water years, 4 dry water years, 2 below normal water years, and 1 above normal water year) but a significant *decrease* in the survival rate by 2.0 – 7.2 percent during 31 years (*e.g.*, 6 dry water years, 4 below normal water years, 5 above normal water years, and 16 wet water years). Overall, CP4 resulted in a 1.4 percent *increase* in the average annual survival rate but a 1.3 percent *decrease* in the median annual survival rate of spring-run Chinook salmon eggs relative to No Action during the 1923 – 2003 simulation period. The average annual number of spring-run egg survivors increased by 755,590 in CP4 relative to No Action, but the median number of egg survivors *decreased* by 716,146.

Fry Mortality

The survival rates and sources of mortality of spring-run Chinook salmon fry using the 1999 – 2006 population average are illustrated in Figures B-21A-B and B-22A-E. The survival rates and sources of mortality of spring-run Chinook salmon fry using the AFRP population goals are illustrated in Figures B-23A-C and B-24A-E.

No Action

Using the 1999 – 2006 population average, base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*) was the only significant source of mortality for spring-run fry in the No Action Alternative. The mortality rate due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) never exceeded 0.1 percent. However, Salmod likely underestimates the rate of mortality of spring-run fry due to habitat constraints due to the model's inability to simulate resource competition and predation among the four runs of Chinook salmon and steelhead. Thermal mortality of spring-run fry was also insignificant. The survival rate of spring-run fry ranged from 76.6 – 83.7 percent throughout the simulation period with an average rate of 80.6 percent (median of 80.9 percent). The number of spring-run fry survivors ranged from 185,038 - 260,068 during 91 percent of the years simulated (74 out of 81 years). The number of spring-run fry survivors dropped to 1,732 – 11,751 during the remaining 9 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during some critical water years.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for winter-run Chinook salmon fry in the No Action Alternative during 93 percent of the years simulated. The mortality rate due to habitat constraints ranged from 0.0 – 17.6 percent with an average rate of 13.0 percent (median of 13.9 percent); the habitat mortality rate exceeded 10 percent during 89 percent of the years simulated (72 out of 81 years). Thermal mortality of spring-run fry was insignificant throughout the simulation period. The survival rate of spring-run fry ranged from 63.2 – 80.5 percent throughout the simulation period. The number of spring-run fry survivors ranged from 16.5 – 23.7 million during 91 percent of the years simulated (74 out of 81 years). The number of spring-run fry survivors dropped to 112,437 – 1,258,308 during the remaining 9 percent of the years simulated primarily due to thermal mortality spring-run eggs pre-spawning and while in the redd during some critical water years.

CP1

Using the 1999 – 2006 population average, similar to No Action, base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), was the only significant source of mortality to spring-run fry in CP1 throughout the simulation period. Thermal mortality and mortality due to habitat constraints were insignificant. Similar to No Action, the survival rate of spring-run fry ranged from 77.7 – 83.7 percent throughout the simulation period. The survival rate of spring-run fry increased by 2.0 percent in CP1 relative to No Action only during 2 percent of the years simulated (2 out of 81 years).

In summary, using the 1999 – 2006 population average, CP1 resulted in little change in the average and median survival rates of spring-run Chinook salmon fry relative to No Action (average survival rate: CP1 = 80.7 percent, No Action = 80.6 percent; median survival rate CP1 = 80.8 percent, No Action = 80.9 percent). The average annual number of spring-run fry survivors *decreased* by 1,261 in CP1 relative to No Action, and the median number of fry survivors *decreased* by 1,356.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for spring-run Chinook salmon fry in CP1 during 91 percent of the years simulated. Similar to No Action, the mortality rate due to habitat constraints ranged from 0.0 – 17.6 percent with an average rate of 13.0 percent (median of 14.1 percent). The habitat mortality rate exceeded 10 percent during 88 percent of the years simulated (71 out of 81 years). The habitat mortality rate increased by 2.2 – 2.5 percent in CP1 relative to No Action during 2 percent of the years simulated (2 out of 81 years). Thermal mortality of fry continued to be insignificant. Similar to No Action, the survival rate of spring-run fry ranged from 63.1 – 80.6 percent in CP1.

In summary, using the AFRP population goals, CP1 resulted in little change in the average and median survival rates of spring-run Chinook salmon fry relative to No Action (average survival rate: CP1 = 68.2 percent, No Action = 68.2 percent; median survival rate CP1 = 67.5 percent, No Action = 67.5 percent). The survival rate of spring-run fry never increased by more than 1.8 percent in CP1 relative to No Action; however the survival rate decreased by 2.3 percent during 1 percent of the years simulated (1 out of 81 years). The average annual number of spring-run fry survivors *decreased* by 129,277 in CP1 relative to No Action, and the median number of fry survivors *decreased* by 79,819.

CP2

Using the 1999 – 2006 population average, similar to No Action, base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), was the only significant source of mortality to spring-run fry in CP2 throughout the simulation period. Thermal mortality and mortality due to habitat constraints were insignificant. Similar to No Action, the survival rate of spring-run fry ranged from 77.4 – 83.7 percent throughout the simulation period. The survival rate of spring-run fry in CP2 never differed from No Action by more than 1.9 percent.

In summary, using the 1999 – 2006 population average, CP2 resulted in little change in the average and median survival rates of spring-run Chinook salmon fry relative to No Action (average survival rate: CP2 = 80.6 percent, No Action = 80.6 percent; median survival rate CP2 = 80.8 percent, No Action = 80.9 percent). The average annual number of spring-run fry survivors *decreased* by 1,429 in CP2 relative to No Action, and the median number of fry survivors *decreased* by 1,944.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for spring-run Chinook salmon fry in CP2 during 91 percent of the years simulated. Similar to No Action, the mortality rate due to habitat constraints ranged from 0.0 – 17.1 percent with an average rate of 12.9 percent (median of 14.0 percent). The habitat mortality rate exceeded 10 percent during 88 percent of the years simulated (71 out of 81 years). The habitat mortality rate increased by 2.0 – 3.3 percent in CP2 relative to No Action during 5 percent of the years simulated (4 out of 81 years) but decreased by 2.5 percent during 1 percent of the years simulated (1 out of 81 years). Thermal mortality of fry continued to be insignificant. Similar to No Action, the survival rate of spring-run fry ranged from 63.1 – 80.7 percent in CP2.

In summary, using the AFRP population goals, CP2 resulted in little change in the average and median survival rates of spring-run Chinook salmon fry relative to No Action (average survival rate: CP2 = 68.2 percent, No Action = 68.2 percent; median survival rate CP2 = 67.6 percent, No Action = 67.5 percent). The survival rate of spring-run fry increased by 2.1 percent in CP2 relative to No Action in only 1 percent of the years simulated (1 out of 81 years); however the survival rate decreased by 2.1 – 3.6 percent during 4 percent of the years simulated (3 out of 81 years) due to increases in mortality related to habitat constraints. The average annual number of spring-run fry survivors *decreased* by 102,306 in CP2 relative to No Action, and the median number of fry survivors *decreased* by 153,266.

CP3 and CP5

Using the 1999 – 2006 population average, similar to No Action, base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), was the only significant source of mortality to spring-run fry in CP3 and CP5 throughout the simulation period. Thermal mortality and mortality due to habitat constraints were insignificant. Similar to No Action, the survival rate of spring-run fry ranged from 76.5 – 83.5 percent throughout the simulation period. The survival rate of spring-run fry in CP3 and CP5 never differed from No Action by more than 2.0 percent.

In summary, using the 1999 – 2006 population average, CP3 and CP5 resulted in little change in the average and median survival rates of spring-run Chinook salmon fry relative to No Action (average survival rate: CP3 and CP5 = 80.6 percent, No Action = 80.6 percent; median survival rate CP3 and CP5 = 81.0 percent, No Action = 80.9 percent). The average annual number of spring-run fry survivors *decreased* by 2,504 in CP3 and CP5 relative to No Action, and the median number of fry survivors *decreased* by 4,099.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for spring-run Chinook salmon fry in CP3 and CP5 during 91 percent of the years simulated. Similar to No Action, the mortality rate due to habitat constraints ranged from 0.0 – 17.4 percent with an average rate of 12.9 percent (median of 14.1 percent). The habitat mortality rate exceeded 10 percent during 88 percent of the years simulated (71 out of 81 years). The habitat mortality rate increased by 2.5 – 4.2 percent in CP3 and CP5 relative to No Action during 2 percent of the years simulated (2 out of 81 years) but decreased by 2.2 – 2.6 percent during 4 percent of the years simulated (3 out of 81 years). Thermal mortality of fry continued to be insignificant. Similar to No Action, the survival rate of spring-run fry ranged from 63.2 – 81.1 percent in CP3 and CP5.

In summary, using the AFRP population goals, CP3 and CP5 resulted in little change in the average and median survival rates of spring-run Chinook salmon fry relative to No Action (average survival rate: CP3 and CP5 = 68.2 percent, No Action = 68.2 percent; median survival rate CP3 and CP5 = 67.6 percent, No Action = 67.5 percent). The survival rate of spring-run fry increased by 2.0 percent in CP3 and CP5 relative to No Action during 1 percent of the years simulated (1 out of 81 years) but decreased by 2.2 – 4.4 percent during 2 percent of the years simulated (2 out of 81 years) due to increases in mortality related to habitat constraints. The average annual number of spring-run fry survivors *decreased* by 188,712 in CP3 and CP5 relative to No Action and the median number of fry survivors *decreased* by 277,937.

CP4

Using the 1999 – 2006 population average, similar to No Action, base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), was the only significant source of mortality to spring-run fry in CP4 throughout the simulation period. Thermal mortality and mortality due to habitat constraints were insignificant. Similar to No Action, the survival rate of spring-run fry ranged from 77.3 – 83.9 percent throughout the simulation period.

In summary, using the 1999 – 2006 population average, the survival rate of spring-run fry in CP4 increased relative to No Action by 2.3 – 3.7 percent during 5 percent of the years simulated (4 out of 81 years). However, CP4 resulted in little change in the average and median survival rates of spring-run Chinook salmon fry relative to No Action (average survival rate: CP4 = 80.9 percent, No Action = 80.6 percent; median survival rate CP4 = 81.2 percent, No Action = 80.9 percent). The average annual number of spring-run fry survivors increased by 6,303 in CP4 relative to No Action, but the median number of fry survivors *decreased* by 5,374.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the greatest source of mortality for spring-run Chinook salmon fry in CP4 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 0.7 – 17.8 percent with an average rate of 13.0 percent (median of 13.7 percent). The habitat mortality rate exceeded 10 percent during 93 percent of the years simulated (75 out of 81 years). The habitat mortality rate increased by 2.7 – 10.9 percent in CP4 relative to No Action during some critical and dry water years representing 10 percent of the years simulated (8 out of 81 years); this was likely due to a reduction in thermal mortality of eggs during some critical and dry water years resulting in an increase in habitat constraints with the increase in number of egg survivors. Mortality due to habitat constraints decreased by 2.0 – 3.7 percent during 9 percent of the years simulated (7 out of 81 years) (mostly wet water years). Thermal mortality of fry continued to be insignificant. Similar to No Action. The survival rate of spring-run fry ranged from 64.1– 79.6 percent in CP4.

In summary, using the AFRP population goals, CP4 resulted in little change in the average and median survival rates of spring-run Chinook salmon fry relative to No Action (average survival rate: CP4 = 68.4 percent, No Action = 68.2 percent; median survival rate CP4 = 67.7 percent, No Action = 67.5 percent). The survival rate of spring-run fry increased by 2.0 – 2.4 percent in CP4 relative to No Action during 6 percent of the years simulated (5 out of 81 years) but decreased by 2.0 – 7.2 percent during 10 percent of the years simulated (8 out of 81 years) due to increases in mortality related to habitat constraints. The number of spring-run fry survivors increased in CP4 relative to No Action by 2,524,224 – 21,443,346 during 7 critical water years, 1 dry water year, and 1 below normal water year primarily due to a decrease in the thermal mortality of spring-run eggs pre-spawning and while in the redd. The average annual number of spring-run fry survivors increased by 739,057 in CP4 relative to No Action, but the median number of fry survivors *decreased* by 334,208.

Pre-Smolt Mortality

The survival rates and sources of mortality of spring-run Chinook salmon pre-smolts using the 1999 – 2006 population average are illustrated in Figures B-25A-C and B-26A-E. The survival rates and sources of mortality of spring-run Chinook salmon pre-smolts using the AFRP population goals are illustrated in Figures B-27A-C and B-28A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for spring-run pre-smolts in the No Action Alternative. However, Salmod likely underestimates the rate of mortality of spring-run pre-smolts due to habitat constraints due to the model's inability to simulate resource competition and predation among the four runs of Chinook salmon and steelhead. The mortality rate due to entrainment in unscreened water diversions ranged from 3.2 – 10.3 percent with an average rate of 5.8 percent (median of 5.8 percent). Thermal mortality of spring-run pre-smolts was insignificant. The survival rate of spring-run pre-smolts ranged from 73.6 – 88.7 percent throughout the simulation period with an average rate of 76.3 percent (median of 75.8 percent). The number of spring-run pre-smolt survivors ranged from 137,098 - 194,958 during 91 percent of the years simulated (74 out of 81 years). The number of spring-run pre-smolts survivors dropped to 1,431 – 9,980 during the remaining 9 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during some critical water years.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for spring-run pre-smolts in the No Action Alternative. The mortality rate due to entrainment in unscreened water diversions ranged from 5.1 – 9.8 percent with an average rate of 6.5 percent (median of 6.4 percent). Mortality due to habitat constraints never exceeded 0.1 percent. However, Salmod likely underestimates the rate of mortality of spring-run pre-smolts due to habitat constraints due to the model's inability to simulate resource competition and predation among the four runs of Chinook salmon and steelhead. Thermal mortality of spring-run pre-smolts was insignificant. The survival rate of spring-run pre-smolts ranged from 73.4 – 85.2 percent throughout the simulation period with an average rate of 76.2 percent (median of 76.0 percent). The number of spring-run pre-smolt survivors ranged from 12.2 – 17.8 million during 91 percent of the years simulated (74 out of 81 years). The number of spring-run pre-smolts survivors dropped to 93,603 – 1,072,378 during the remaining 9 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during some critical water years.

CP1

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only significant source of mortality to spring-run pre-smolts in CP1 throughout the simulation period. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 3.3 – 10.8 percent with an average rate of 5.8 percent (median of 5.8 percent). Also similar to No Action, the survival rate of spring-run pre-smolts ranged from 73.9 – 87.9 percent throughout the simulation period. The survival rate of spring-run pre-smolts in CP1 increased by 2.9 – 3.0 percent during 2 percent of the years simulated (2 out of 81 years) but decreased by 3.2 percent during 1 percent of the years simulated (1 out of 81 years).

In summary, using the 1999 – 2006 population average, CP1 resulted in little change in the average and median survival rates of spring-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP1 = 76.6 percent, No Action = 76.3 percent; median survival rate CP1 = 76.0 percent, No Action = 75.8 percent). The average annual number of spring-run pre-smolt survivors *decreased* by 298 in CP1 relative to No Action, and the median number of pre-smolt survivors *decreased* by 143.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only significant source of mortality to spring-run pre-smolts in CP1 throughout the simulation period. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 5.1 – 10.4 percent with an average rate of 6.6 percent (median of 6.5 percent). Also similar to No Action, the survival rate of spring-run pre-smolts ranged from 73.4 – 86.3 percent throughout the simulation period. The survival rate of spring-run pre-smolts in CP1 never differed by more than 1.4 percent from No Action.

In summary, using the AFRP population goals, CP1 resulted in little change in the average and median survival rates of spring-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP1 = 76.5 percent, No Action = 76.2 percent; median survival rate CP1 = 76.2 percent, No Action = 76.0 percent). The average annual number of spring-run pre-smolt survivors *decreased* by 43,992 in CP1 relative to No Action, and the median number of pre-smolt survivors *decreased* by 29,279.

CP2

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only significant source of mortality to spring-run pre-smolts in CP2 throughout the simulation period. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 3.3 – 10.4 percent with an average rate of 5.9 percent (median of 5.9 percent). Also similar to No Action, the survival rate of spring-run pre-smolts ranged from 73.9 – 87.8 percent throughout the simulation period. The survival rate of spring-run pre-smolts in CP2 increased by 2.6 – 3.1 percent during 4 percent of the years simulated (3 out of 81 years) but decreased by 3.0 percent during 1 percent of the years simulated (1 out of 81 years).

In summary, using the 1999 – 2006 population average, CP2 resulted in little change in the average and median survival rates of spring-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP2 = 76.9 percent, No Action = 76.3 percent; median survival rate CP2 = 76.2 percent, No Action = 75.8 percent). The average annual number of spring-run pre-smolt survivors increased by 36 in CP2 relative to No Action, but the median number of pre-smolt survivors *decreased* by 681.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only significant source of mortality to spring-run pre-smolts in CP2 throughout the simulation period. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 5.1 – 9.7 percent with an average rate of 6.6 percent (median of 6.5 percent). Also similar to No Action, the survival rate of spring-run pre-smolts ranged from 73.4 – 86.2 percent throughout the simulation period. The survival rate of spring-run pre-smolts in CP2 never differed by more than 1.3 percent from No Action.

In summary, using the AFRP population goals, CP2 resulted in little change in the average and median survival rates of spring-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP2 = 76.7 percent, No Action = 76.2 percent; median survival rate CP2 = 76.5 percent, No Action = 76.0 percent). The average annual number of spring-run pre-smolt survivors increased by 19,355 in CP2 relative to No Action, but the median number of pre-smolt survivors *decreased* by 25,498.

CP3 and CP5

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only significant source of mortality to spring-run pre-smolts in CP3 and CP5 throughout the simulation period. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 3.8 – 10.4 percent with an average rate of 5.9 percent (median of 5.9 percent). Also similar to No Action, the survival rate of spring-run pre-smolts ranged from 73.9 – 87.2 percent throughout the simulation period. The survival rate of spring-run pre-smolts in CP3 and CP5 increased by 2.3 – 2.6 percent during 2 percent of the years simulated (2 out of 81 years) but decreased by 2.5 - 3.0 percent during 2 percent of the years simulated (2 out of 81 years).

In summary, using the 1999 – 2006 population average, CP3 and CP5 resulted in little change in the average and median survival rates of spring-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP3 and CP5 = 77.0 percent, No Action = 76.3 percent; median survival rate CP3 and CP5 = 76.4 percent, No Action = 75.8 percent). The average annual number of spring-run pre-smolt survivors *decreased* by 353 in CP3 and CP5 relative to No Action, and the median number of pre-smolt survivors *decreased* by 1,532.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only significant source of mortality to spring-run pre-smolts in CP3 and CP5 throughout the simulation period. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 5.4 – 9.7 percent with an average rate of 6.7 percent (median of 6.7 percent). Also similar to No Action, the survival rate of spring-run pre-smolts ranged from 73.4 – 86.3 percent throughout the simulation period. The survival rate of spring-run pre-smolts in CP3 and CP5 decreased by 2.3 percent only during 1 percent of the years simulated (1 out of 81 years).

In summary, using the AFRP population goals, CP3 and CP5 resulted in little change in the average and median survival rates of spring-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP3 and CP5 = 76.8 percent, No Action = 76.2 percent; median survival rate CP3 and CP5 = 76.9 percent, No Action = 76.0 percent). The average annual number of spring-run pre-smolt survivors *decreased* by 5,771 in CP3 and CP5 relative to No Action, and the median number of pre-smolt survivors *decreased* by 58,786.

CP4

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only significant source of mortality to spring-run pre-smolts in CP4 throughout the simulation period. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 3.5 – 8.0 percent with an average rate of 5.9 percent (median of 5.9 percent). Also similar to No Action, the survival rate of spring-run pre-smolts ranged from 73.9 – 82.1 percent throughout the simulation period. The survival rate of spring-run pre-smolts in CP4 increased by 2.0 – 3.0 percent during 5 percent of the years simulated (4 out of 81 years) but decreased by 2.3 – 13.4 percent during 6 critical water years and 1 dry water year representing 9 percent of the years simulated (7 out of 81 years).

In summary, despite the decrease in survival rates during some critical and dry water years, CP4 resulted in little change in the average and median survival rates of spring-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP4 = 76.7 percent, No Action = 76.3 percent; median survival rate CP4 = 76.5 percent, No Action = 75.8 percent). The number of spring-run pre-smolt survivors actually increased relative to No Action by 97,113 – 174,496 during 3 critical water years and 1 dry water year due to significant decreases in thermal mortality of spring-run eggs during those years. The average annual number of spring-run pre-smolt survivors increased by 7,001 in CP4 relative to No Action, but the median number of pre-smolt survivors *decreased* by 1,904.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only significant source of mortality to spring-run pre-smolts in CP4 throughout the simulation period. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 4.8 – 8.3 percent with an average rate of 6.6 percent (median of 6.6 percent). Also similar to No Action, the survival rate of spring-run pre-smolts ranged from 73.3 – 81.0 percent throughout the simulation period. The survival rate of spring-run pre-smolts in CP4 increased by 2.1 – 2.4 percent during 2 percent of the years simulated (2 out of 81 years) but decreased by 5.1 – 9.5 percent during 5 critical water years and 1 dry water year representing 7 percent of the years simulated (6 out of 81 years).

In summary, despite the decrease in survival rates during some critical and dry water years, CP4 resulted in little change in the average and median survival rates of spring-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP4 = 76.7 percent, No Action = 76.2 percent; median survival rate CP4 = 76.8 percent, No Action = 76.0 percent). The number of spring-run pre-smolt survivors actually increased relative to No Action by 2,632,256 – 15,880,421 during the same 5 critical water years and 1 dry water year that showed decreases in survival rates; this was due to significant decreases in thermal mortality of spring-run eggs during those years. The average annual number of spring-run pre-smolt survivors increased by 753,592 in CP4 relative to No Action, but the median number of pre-smolt survivors *decreased* by 42,818.

Immature Smolt Mortality

The survival rates and sources of mortality of spring-run Chinook salmon immature smolts using the 1999 – 2006 population average are illustrated in Figures B-29A and B-30A-E. The survival rates and sources of mortality of spring-run Chinook salmon immature smolts using the AFRP population goals are illustrated in Figures B-31A and B-32A-E.

No Action

Using the 1999 – 2006 population average, there were no significant sources of mortality of spring-run Chinook salmon in the No Action Alternative throughout the simulation period. Mortality due to unsuitable temperatures, unscreened water diversions, and habitat constraints were insignificant. However, Salmod likely underestimates the rate of mortality of spring-run immature smolts due to habitat constraints due to the model’s inability to simulate resource competition and predation among the four runs of Chinook salmon and steelhead. The survival rate of spring-run immature smolts ranged from 99.6 – 100.0 percent throughout the simulation period. The number of spring-run immature smolt survivors ranged from 136,996 - 194,858 during 91 percent of the years simulated (74 out of 81 years). The number of spring-run immature smolts survivors dropped to 1,431 – 9,980 during the remaining 9 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during some critical water years.

Using the AFRP population goals, there were no significant sources of mortality of spring-run Chinook salmon in the No Action Alternative throughout the simulation period. Mortality due to unsuitable temperatures, unscreened water diversions, and habitat constraints were insignificant. However, Salmod likely underestimates the rate of mortality of spring-run immature smolts due to habitat constraints due to the model's inability to simulate resource competition and predation among the four runs of Chinook salmon and steelhead. The survival rate of spring-run immature smolts ranged from 99.6 – 100.0 percent throughout the simulation period. The number of spring-run immature smolt survivors ranged from 12,196,492 - 17,814,014 during 91 percent of the years simulated (74 out of 81 years). The number of spring-run immature smolts survivors dropped to 93,603 – 1,072,378 during the remaining 9 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during some critical water years.

CP1

Using the 1999 – 2006 population average, like in No Action, there were no significant sources of mortality of spring-run Chinook salmon in CP1 throughout the simulation period. Mortality due to unsuitable temperatures, unscreened water diversions, and habitat constraints were insignificant. The survival rate of spring-run immature smolts in CP1 as in No Action ranged from 99.6 – 100.0 percent throughout the simulation period. The number of spring-run immature smolt survivors ranged from 134,525 - 194,893 during 91 percent of the years simulated (74 out of 81 years). The number of spring-run immature smolts survivors dropped to 2,529 – 11,248 during the remaining 9 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during some critical water years. The average annual number of spring-run immature smolt survivors *decreased* by 295 in CP1 relative to No Action, and the median number of immature smolt survivors *decreased* by 154.

Using the AFRP population goals, like in No Action, there were no significant sources of mortality of spring-run Chinook salmon in CP1 throughout the simulation period. Mortality due to unsuitable Similar to No Action, the survival rate of spring-run immature smolts in CP1 ranged from 99.8 – 100.0 percent throughout the simulation period. The number of spring-run immature smolt survivors ranged from 11,456,039 - 17,589,070 during 91 percent of the years simulated (74 out of 81 years). The number of spring-run immature smolts survivors dropped to 133,977 – 936,222 during the remaining 9 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during some critical water years. The average annual number of spring-run immature smolt survivors *decreased* by 43,388 in CP1 relative to No Action, and the median number of immature smolt survivors *decreased* by 13,423.

CP2

Using the 1999 – 2006 population average, like in No Action, there were no significant sources of mortality of spring-run Chinook salmon in CP2 throughout the simulation period. Mortality due to unsuitable temperatures, unscreened water diversions, and habitat constraints were insignificant. Similar to No Action, the survival rate of spring-run immature smolts in CP2 ranged from 99.8 – 100.0 percent throughout the simulation period. The number of spring-run immature smolt survivors ranged from 140,009 - 193,787 during 91 percent of the years simulated (74 out of 81 years). The number of spring-run immature smolts survivors dropped to

2,161 – 11,491 during the remaining 9 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during some critical water years. The average annual number of spring-run immature smolt survivors increased by 47 in CP2 relative to No Action, but the median number of immature smolt survivors *decreased* by 692.

Using the AFRP population goals, like in No Action, there were no significant sources of mortality of spring-run Chinook salmon in CP2 throughout the simulation period. Mortality due to unsuitable Similar to No Action, the survival rate of spring-run immature smolts in CP2 ranged from 99.8 – 100.0 percent throughout the simulation period. The number of spring-run immature smolt survivors ranged from 12,254,866 - 17,543,658 during 91 percent of the years simulated (74 out of 81 years). The number of spring-run immature smolts survivors dropped to 136,231 – 947,159 during the remaining 9 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during some critical water years. The average annual number of spring-run immature smolt survivors increased by 47 in CP2 relative to No Action, but the median number of immature smolt survivors *decreased* by 692.

CP3 and CP5

Using the 1999 – 2006 population average, like in No Action, there were no significant sources of mortality of spring-run Chinook salmon in CP3 and CP5 throughout the simulation period. Mortality due to unsuitable temperatures, unscreened water diversions, and habitat constraints were insignificant. Similar to No Action, the survival rate of spring-run immature smolts in CP3 and CP5 ranged from 99.8 – 100.0 percent throughout the simulation period. The number of spring-run immature smolt survivors ranged from 143,414 - 195,426 during 91 percent of the years simulated (74 out of 81 years). The number of spring-run immature smolts survivors dropped to 2,982 – 12,233 during the remaining 9 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during some critical water years. The average annual number of spring-run immature smolt survivors increased by 20,477 in CP3 and CP5 relative to No Action, but the median number of immature smolt survivors *decreased* by 25,586.

Using the AFRP population goals, like in No Action, there were no significant sources of mortality of spring-run Chinook salmon in CP3 and CP5 throughout the simulation period. Mortality due to unsuitable Similar to No Action, the survival rate of spring-run immature smolts in CP3 and CP5 ranged from 99.8 – 100.0 percent throughout the simulation period. The number of spring-run immature smolt survivors ranged from 12,619,637 - 17,592,497 during 91 percent of the years simulated (74 out of 81 years). The number of spring-run immature smolts survivors dropped to 169,421 – 1,004,345 during the remaining 9 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during some critical water years. The average annual number of spring-run immature smolt survivors *decreased* by 4,358 in CP3 and CP5 relative to No Action, and the median number of immature smolt survivors *decreased* by 58,786.

CP4

Using the 1999 – 2006 population average, like in No Action, there were no significant sources of mortality of spring-run Chinook salmon in CP4 throughout the simulation period. Mortality due to unsuitable temperatures, unscreened water diversions, and habitat constraints were insignificant. Similar to No Action, the survival rate of spring-run immature smolts in CP4 ranged from 99.7 – 100.0 percent throughout the simulation period. The number of spring-run immature smolt survivors ranged from 100,379 - 194,179 during 96 percent of the years simulated (78 out of 81 years). The number of spring-run immature smolts survivors dropped to 18,325 – 49,846 during the remaining 4 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during three critical water years. The number of spring-run immature smolt survivors increased by 93,866 - 174,445 during 3 critical water years and 1 dry water year in CP4 relative to No Action due to a decrease in thermal mortality of spring-run Chinook salmon eggs during those years. The average annual number of spring-run immature smolt survivors increased by 7,015 in CP4 relative to No Action, but the median number of immature smolt survivors *decreased* by 1,905.

Using the AFRP population goals, like in No Action, there were no significant sources of mortality of spring-run Chinook salmon in CP4 throughout the simulation period. Mortality due to unsuitable temperatures, unscreened water diversions, and habitat constraints were insignificant. Similar to No Action, the survival rate of spring-run immature smolts in CP4 ranged from 99.5 – 100.0 percent throughout the simulation period. The number of spring-run immature smolt survivors ranged from 9,721,014 - 17,825,756 during 96 percent of the years simulated (78 out of 81 years). The number of spring-run immature smolts survivors dropped to 1,739,399 – 4,611,786 during the remaining 4 percent of the years simulated primarily due to thermal mortality of spring-run eggs pre-spawning and while in the redd during three critical water years. The number of spring-run immature smolt survivors increased by 9,186,857 - 15,871,703 during 3 critical water years and 1 dry water year in CP4 relative to No Action due to a decrease in thermal mortality of spring-run Chinook salmon eggs during those years. The average annual number of spring-run immature smolt survivors increased by 755,091 in CP4 relative to No Action, but the median number of immature smolt survivors *decreased* by 42,818.

Fall-run Chinook Salmon

Egg Mortality

The survival rates and sources of mortality of fall-run Chinook salmon eggs using the 1999 – 2006 population average are illustrated in Figures B-33A-E and B-34A-E. The survival rates and sources of mortality of fall-run Chinook salmon eggs using the AFRP population goals are illustrated in Figures B-35A-D and B-36A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) were the greatest sources of mortality for fall-run Chinook salmon eggs in the No Action Alternative during most years simulated. The superimposition mortality rate ranged from 0.0 – 45.6 percent with an average rate of 7.3 percent (median of 0.0 percent). Superimposition mortality was significant (greater than 2 percent) during 33 percent of the years simulated (27 out of 81 years). The incubation mortality rate ranged from 0.0 – 46.1 percent with an average rate of 5.6 percent (median of 0.9 percent). Incubation mortality was significant (greater than 2 percent) during 23 percent of the years simulated (19 out of 81 years). Pre-spawning thermal mortality was restricted to 10 percent of the years simulated (8 out of 81 years); this occurred during 7 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, 1992, and 2001) and 1 out of 17 dry water years (1932) when the mortality rate ranged from 3.3 – 89.3 percent. Thermal mortality of eggs while in the redd (eggs-temp) was restricted to 5 percent of the years simulated (4 out of 81 years); this occurred during 3 out of 13 critical water years (1933, 1988, and 1992) and 1 out of 17 dry water years (1932) when the eggs-temp mortality rate ranged from 2.7 – 12.4 percent. The survival rate of fall-run eggs ranged from 43.1 – 56.1 percent during 64 percent of the years simulated (52 out of 81 years) but was reduced to 0.3 – 38.9 percent during the remaining 36 percent of the years. The number of fall-run eggs surviving exceeded 60 million during 64 percent of the years simulated.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) were the greatest sources of mortality for fall-run Chinook salmon eggs in the No Action Alternative during most years simulated. The superimposition mortality rate ranged from 0.0 – 58.6 percent with an average rate of 10.6 percent (median of 0.1 percent). Superimposition mortality was significant (greater than 2 percent) during 38 percent of the years simulated (31 out of 81 years). The incubation mortality rate ranged from 0.0 – 40.6 percent with an average rate of 4.9 percent (median of 1.2 percent). Incubation mortality was significant (greater than 2 percent) during 25 percent of the years simulated (20 out of 81 years). Pre-spawning thermal mortality was restricted to 10 percent of the years simulated (8 out of 81 years); this occurred during 7 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, 1992, and 2001) and 1 out of 17 dry water years (1932) when the mortality rate ranged from 3.3 – 89.2 percent. Thermal mortality of eggs while in the redd (eggs-temp) was restricted to 5 percent of the years simulated (4 out of 81 years); this occurred during 3 out of 13 critical water years (1933, 1988, and 1992) and 1 out of 17 dry water years (1932) when the eggs-temp mortality rate ranged from 2.7 – 12.4 percent. The survival rate of fall-run eggs ranged from 40.8 – 55.3 percent during 62 percent of the years simulated (50 out of 81 years) but was reduced to 0.2 – 38.9 percent during the remaining 38 percent of the years. The number of fall-run eggs surviving exceeded 100 million during 59 percent of the years simulated.

CP1

Using the 1999 – 2006 population average, other than base mortality, mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for fall-run Chinook salmon eggs in CP1 during most years simulated. Similar to No Action, the superimposition mortality rate in CP1 ranged from 0.0 – 45.6 percent with an average rate of 7.0 percent (median of 0.0 percent). Superimposition mortality was significant (greater than 2 percent) during 32 percent of the years simulated (26 out of 81 years). The incubation mortality rate in CP1 was also similar to No Action ranging from 0.0 – 46.3 percent with an average rate of 5.5 percent (median of 0.9 percent). Incubation mortality was significant (greater than 2 percent) during 25 percent of the years simulated (20 out of 81 years). As in No Action, pre-spawning thermal mortality in CP1 was restricted to 10 percent of the years simulated (8 out of 81 years); this occurred during 7 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, 1992, and 2001) and 1 out of 17 dry water years (1932). CP1 reduced the pre-spawning thermal mortality rate relative to No Action by 4.3 – 33.3 percent during 4 critical water years (1931, 1933, 1934, and 1977) and 1 dry water year (1932). However, CP1 increased the pre-spawning thermal mortality rate relative to No Action by 2.0 – 8.2 percent during 3 critical water years (1924, 1992, and 2001). CP1 resulted in a slight increase in thermal mortality of eggs while in the redd relative to No Action by 0.6 – 1.5 percent during 4 critical water years.

In summary, using the 1999 – 2006 population average, CP1 resulted in a significant *increase* (greater than 2 percent) in the survival rate of fall-run eggs by 2.4 – 16.7 percent during 8 years (*e.g.*, 3 critical water years, 2 dry water years, 2 below normal water years, and 1 above normal water year) but a significant *decrease* in the survival rate by 2.0 – 4.2 percent during 3 years (e.g., 2 critical and 1 wet water year). The average annual number of fall-run egg survivors increased by 901,999 in CP1 relative to No Action, and the median number of egg survivors increased by 132,577.

Using the AFRP population goals, other than base mortality, mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for fall-run Chinook salmon eggs in CP1 during most years simulated. Similar to No Action, the superimposition mortality rate in CP1 ranged from 0.0 – 58.6 percent with an average rate of 10.5 percent (median of 0.1 percent). Superimposition mortality was significant (greater than 2 percent) during 38 percent of the years simulated (31 out of 81 years). The incubation mortality rate in CP1 was also similar to No Action ranging from 0.0 – 40.4 percent with an average rate of 4.8 percent (median of 0.8 percent). Incubation mortality was significant (greater than 2 percent) during 25 percent of the years simulated (20 out of 81 years). As in No Action, pre-spawning thermal mortality in CP1 was restricted to 10 percent of the years simulated (8 out of 81 years); this occurred during 7 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, 1992, and 2001) and 1 out of 17 dry water years (1932). CP1 reduced the pre-spawning thermal mortality rate relative to No Action by 3.9 – 27.1 percent during 4 critical water years (1931, 1933, 1934, and 1977) and 1 dry water year (1932). However, CP1 increased the pre-spawning thermal mortality rate relative to No Action by 3.3 percent during the critical water year 1924. CP1 resulted in a slight increase in thermal mortality of eggs while in the redd relative to No Action by 0.6 – 1.5 percent during 6 critical water years.

In summary, using the AFRP population goals, CP1 resulted in a significant *increase* (greater than 2 percent) in the survival rate of fall-run eggs by 2.1 – 16.6 percent during 9 years (*e.g.*, 3 critical water years, 2 dry water years, 2 below normal water years, 1 above normal water year, and 1 wet water year) but a significant *decrease* in the survival rate by 2.6 – 4.2 percent during 2 years (e.g., 1 critical and 1 wet water year). The average annual number of fall-run egg survivors increased by 1,374,937 in CP1 relative to No Action, and the median number of egg survivors increased by 207,410.

CP2

Using the 1999 – 2006 population average, other than base mortality, mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for fall-run Chinook salmon eggs in CP2 during most years simulated. The superimposition mortality rate in CP2 ranged from 0.0 – 45.6 percent with an average rate of 6.6 percent that decreased slightly relative to No Action (7.3 percent in No Action). Superimposition mortality was significant (greater than 2 percent) during 28 percent of the years simulated (23 out of 81 years). The incubation mortality rate in CP2 was similar to No Action ranging from 0.0 – 46.5 percent with an average rate of 5.5 percent (median of 0.9 percent). Incubation mortality was significant (greater than 2 percent) during 25 percent of the years simulated (20 out of 81 years). As in No Action, pre-spawning thermal mortality in CP2 was restricted to 10 percent of the years simulated (8 out of 81 years); this occurred during 7 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, 1992, and 2001) and 1 out of 17 dry water years (1932). CP2 reduced the pre-spawning thermal mortality rate relative to No Action by 3.9 – 27.2 percent during 4 critical water years (1931, 1933, 1934, and 1977) and 1 dry water year (1932). However, CP2 increased the pre-spawning thermal mortality rate relative to No Action by 3.3 percent during the critical water year 1924. CP2 resulted in a slight increase in thermal mortality of eggs while in the redd relative to No Action by 0.6 – 1.4 percent during 4 critical water year but a slight decrease by 1.1 percent during the critical water year 1994.

In summary, using the 1999 - 2006 population average, CP2 resulted in a significant *increase* (greater than 2 percent) in the survival rate of fall-run eggs by 2.3 – 13.6 percent during 14 years (*e.g.*, 3 critical water years, 5 dry water years, 4 below normal water years, 1 above normal water year, and 1 wet water year) but a significant *decrease* in the survival rate by 3.4 percent during the wet water year 1999. The average annual number of fall-run egg survivors increased by 1,253,217 in CP2 relative to No Action, and the median number of egg survivors increased by 140,772.

Using the AFRP population goals, other than base mortality, other than base mortality, mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for fall-run Chinook salmon eggs in CP2 during most years simulated. The superimposition mortality rate in CP2 ranged from 0.0 – 58.6 percent with an average rate of 10.1 percent that decreased slightly relative to No Action (10.9 percent in No Action). Superimposition mortality was significant (greater than 2 percent) during 38 percent of the years simulated (31 out of 81 years). The incubation mortality rate in CP2 was similar to No Action ranging from 0.0 – 40.6 percent with an average rate of 4.8 percent (median of 0.8 percent). Incubation mortality was significant (greater than 2 percent) during 25 percent of the years simulated (20 out of 81 years). As in No Action, pre-spawning thermal mortality in CP2 was restricted to 10 percent of the years simulated (8 out of 81 years); this occurred during 7 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, 1992, and 2001) and 1 out of 17 dry water years (1932). CP2 reduced the pre-spawning thermal mortality rate relative to No Action by 3.9 – 27.2 percent during 4 critical water years (1931, 1933, 1934, and 1977) and 1 dry water year (1932). However, CP2 increased the pre-spawning thermal mortality rate relative to No Action by 3.3 percent during the critical water year 1924. CP2 resulted in a slight increase in thermal mortality of eggs while in the redd relative to No Action by 0.6 – 1.4 percent during 4 critical water year but a slight decrease by 1.1 percent during the critical water year 1994.

In summary, using the AFRP population goals, CP2 resulted in a significant *increase* (greater than 2 percent) in the survival rate of fall-run eggs by 2.0 – 13.6 percent during 14 years (*e.g.*, 3 critical water years, 5 dry water years, 4 below normal water years, 1 above normal water year, and 1 wet water year) but a significant *decrease* in the survival rate by 3.4 percent during the wet water year 1999. The average annual number of fall-run egg survivors increased by 2,026,190 in CP2 relative to No Action, and the median number of egg survivors increased by 173,231.

CP3 and CP5

Using the 1999 – 2006 population average, other than base mortality, mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for fall-run Chinook salmon eggs in CP3 and CP5 during most years simulated. The superimposition mortality rate in CP3 and CP5 ranged from 0.0 – 45.6 percent with an average rate of 6.3 percent that decreased slightly relative to No Action (7.3 percent in No Action). Superimposition mortality was significant (greater than 2 percent) during 32 percent of the years simulated (26 out of 81 years). The superimposition mortality rate in CP3 and CP5 decreased by 3.7 – 17.1 percent relative to No Action during 4 years (3 dry and 1 below normal water year) but increased by 2.8 percent during the wet water year 1999. The incubation mortality rate in CP3 and CP5 was similar to No Action ranging from 0.0 – 47.7 percent with an average rate of 5.3 percent (median of 1.0 percent). Incubation mortality was significant (greater than 2 percent) during 22 percent of the years simulated (18 out of 81 years). As in No Action, pre-spawning thermal mortality in CP3 and CP5 was restricted to 10 percent of the years simulated (8 out of 81 years); this occurred during 7 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, 1992, and 2001) and 1 out of 17 dry water years (1932). CP3 and CP5 reduced the pre-spawning thermal mortality rate relative to No Action by 3.0 – 28.7 percent during 4 critical water years (1931, 1933, 1934, and 1977) and 1 dry water year (1932). CP3 and CP5 resulted in a slight increase in thermal mortality of eggs while in the redd relative to No Action by 0.8 – 2.2 percent during 3 critical water years but a slight decrease by 0.7 – 1.3 percent during 2 critical water years.

In summary, using the 1999 - 2006 population average, CP3 and CP5 resulted in a significant *increase* (greater than 2 percent) in the survival rate of fall-run eggs by 2.9 – 15.7 percent during 15 years (*e.g.*, 3 critical water years, 6 dry water years, 4 below normal water years, 1 above normal water year, and 1 wet water year) but a significant *decrease* in the survival rate by 3.6 percent during the wet water year 1999. The average annual number of fall-run egg survivors increased by 2,026,190 in CP3 and CP5 relative to No Action, but the median number of egg survivors *decreased* by 51,714.

Using the AFRP population goals, other than base mortality, other than base mortality, mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for fall-run Chinook salmon eggs in CP3 and CP5 during most years simulated. The superimposition mortality rate in CP3 and CP5 ranged from 0.0 – 58.6 percent with an average rate of 9.8 percent that decreased slightly relative to No Action (10.9 percent in No Action). Superimposition mortality was significant (greater than 2 percent) during 38 percent of the years simulated (31 out of 81 years). The superimposition mortality rate in CP3 and CP5 decreased by 2.0 – 21.6 percent relative to No Action during 9 years (2 dry water years, 3 below normal water years, 1 above normal water year, and 2 wet water years). The incubation mortality rate in CP3 and CP5 was similar to No Action ranging from 0.0 – 41.6 percent with an average rate of 4.5 percent (median of 0.9 percent). Incubation mortality was significant (greater than 2 percent) during 22 percent of the years simulated (18 out of 81 years). As in No Action, pre-spawning thermal mortality in CP3 and CP5 was restricted to 10 percent of the years simulated (8 out of 81 years); this occurred during 7 out of 13 critical water years (1924, 1931, 1933, 1934, 1977, 1992, and 2001) and 1 out of 17 dry water years (1932). CP3 and CP5 reduced the pre-spawning thermal mortality rate relative to No Action by 3.0 – 28.6 percent during 4 critical water years (1931, 1933, 1934, and 1977) and 1 dry water year (1932). CP3 and CP5 resulted in a slight increase in thermal mortality of eggs while in the redd relative to No Action by 0.6 – 2.2 percent during 4 critical water years but a slight decrease by 0.7 – 1.3 percent during 2 critical water years.

In summary, using the AFRP population goals, CP3 and CP5 resulted in a significant *increase* (greater than 2 percent) in the survival rate of fall-run eggs by 2.9 – 14.4 percent during 14 years (*e.g.*, 3 critical water years, 5 dry water years, 4 below normal water years, 1 above normal water year, and 1 wet water year) but a significant *decrease* in the survival rate by 3.6 percent during the wet water year 1999. The average annual number of fall-run egg survivors increased by 3,064,021 in CP3 and CP5 relative to No Action, and the median number of egg survivors increased by 171,759.

CP4

Using the 1999 – 2006 population average, other than base mortality, mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for fall-run Chinook salmon eggs in CP4 during most years simulated. The superimposition mortality rate in CP4 ranged from 0.0 – 45.6 percent with an average rate of 7.0 percent that decreased slightly relative to No Action (7.3 percent in No Action). Superimposition mortality was significant (greater than 2 percent) during 32 percent of the years simulated (26 out of 81 years). The incubation mortality rate in CP4 was similar to No Action ranging from 0.0 – 46.5 percent with an average rate of 5.6 percent (median of 1.2 percent). Incubation mortality was significant (greater than 2 percent) during 25 percent of the years simulated (20 out of 81 years). Significant (greater than 2 percent) pre-spawning thermal mortality in CP4 was restricted to 4 percent of the years simulated (3 out of 81 years) compared to 10 percent of the years (8 out of 81 years) in the other alternatives. In CP4, significant pre-spawning mortality occurred during 3 out of 13 critical water years (1934, 1977, and 2001) and ranged from 3.2 – 18.0 percent. CP4 reduced the pre-spawning thermal mortality rate relative to No Action by 14.8 – 69.9 percent during 6 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) and by 82.8 percent during the dry water year 1932. However, CP4 resulted in an increase in the thermal mortality of eggs while in the redd by 1.7 – 6.3 percent during 6 years (5 critical and 1 dry water year).

In summary, using the 1999 - 2006 population average, CP4 resulted in a significant *increase* (greater than 2 percent) in the survival rate of fall-run eggs by 2.3 – 44.0 percent during 12 years (*e.g.*, 7 critical water years, 2 dry water years, 2 below normal water years, and 1 above normal water year) but a significant *decrease* in the survival rate by 2.5 - 3.4 percent during 2 years (*e.g.*, 1 below normal water year and 1 wet water year). Therefore, CP4 resulted in a significant *increase* in the survival rate of fall-run Chinook salmon eggs during 15 percent of the years simulated but a significant decrease during 2 percent of the years. The survival rate increased by *more than 10* percent in CP4 relative to No Action during 6 years (5 critical and 1 dry water year) or 7 percent of the years simulated. The average annual number of fall-run egg survivors increased by 3,705,253 in CP4 relative to No Action, and the median number of egg survivors increased by 220,827.

Using the AFRP population goals, other than base mortality, mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for fall-run Chinook salmon eggs in CP4 during most years simulated. The superimposition mortality rate in CP4 ranged from 0.0 – 58.6 percent with an average rate of 10.6 percent that decreased slightly relative to No Action (10.9 percent in No Action). Superimposition mortality was significant (greater than 2 percent) during 40 percent of the years simulated (32 out of 81 years). The incubation mortality rate in CP4 was similar to No Action ranging from 0.0 – 40.6 percent with an average rate of 4.9 percent (median of 1.2 percent). Incubation mortality was significant (greater than 2 percent) during 25 percent of the years simulated (20 out of 81 years). Significant (greater than 2 percent) pre-spawning thermal mortality in CP4 was restricted to 4 percent of the years simulated (3 out of 81 years) compared to 10 percent of the years (8 out of 81 years) in the other alternatives. In CP4, significant pre-spawning mortality occurred during 3 out of 13 critical water years (1934, 1977, and 2001) and ranged from 3.2 – 18.0 percent. CP4 reduced the pre-spawning thermal mortality rate relative to No Action by 14.8 – 69.9 percent during 6 critical water years (1924, 1931, 1933, 1934, 1977, and 1992) and by 87.6 percent during the dry water year 1932. However, CP4 resulted in an increase in the thermal mortality of eggs while in the redd by 1.7 – 6.3 percent during 6 years (5 critical and 1 dry water year).

In summary, using the AFRP population goals, CP4 resulted in a significant *increase* (greater than 2 percent) in the survival rate of fall-run eggs by 2.0 – 43.9 percent during 13 years (*e.g.*, 7 critical water years, 2 dry water years, 2 below normal water years, 1 above normal water year, and 1 wet water year) but a significant *decrease* in the survival rate by 2.0 - 3.4 percent during 2 years (*e.g.*, 1 above normal water year and 1 wet water year). Therefore, CP4 resulted in a significant *increase* in the survival rate of fall-run Chinook salmon eggs during 16 percent of the years simulated but a significant decrease during 2 percent of the years. The survival rate increased by *more than 10* percent in CP4 relative to No Action during 6 years (5 critical and 1 dry water year) or 7 percent of the years simulated. The average annual number of fall-run egg survivors increased by 5,632,761 in CP4 relative to No Action, and the median number of egg survivors increased by 361,544.

Fry Mortality

The survival rates and sources of mortality of fall-run Chinook salmon fry using the 1999 – 2006 population average are illustrated in Figures B-37A-C and B-38A-E. The survival rates and sources of mortality of fall-run Chinook salmon fry using the AFRP population goals are illustrated in Figures B-39A-C and B-40A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for fall-run Chinook salmon fry in the No Action Alternative throughout the simulation period. The mortality rate due to habitat constraints ranged from 6.6 – 37.3 percent with an average rate of 27.0 percent (median of 30.7 percent). The survival rate of fall-run fry ranged from 48.2 – 77.9 percent throughout the simulation period. The number of fall-run fry survivors ranged from 39 – 49 million during 65 percent of the years simulated (53 out of 81 years). The number of fall-run fry survivors dropped to 4.9 – 38.8 million during the remaining 35 percent of the years simulated primarily due to superimposition and pre-spawning thermal mortality of fall-run eggs combined with habitat-related mortality of fall-run fry.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for fall-run Chinook salmon fry in the No Action Alternative throughout the simulation period. The mortality rate due to habitat constraints ranged from 6.0 – 50.2 percent with an average rate of 37.3 percent (median of 43.4 percent). The survival rate of fall-run fry ranged from 36.3 – 78.5 percent throughout the simulation period. The number of fall-run fry survivors ranged from 47.6 – 56.4 million during 63 percent of the years simulated (51 out of 81 years). The number of fall-run fry survivors dropped to 5.0 – 45.3 million during the remaining 37 percent of the years simulated primarily due to superimposition and pre-spawning thermal mortality of fall-run eggs combined with habitat-related mortality of fall-run fry.

CP1

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for fall-run Chinook salmon fry in CP1 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 5.2 – 36.6 percent with an average rate of 27.4 percent (median of 30.6 percent). The habitat mortality rate decreased by 2.1 – 2.7 percent in CP1 relative to No Action during 4 percent of the years simulated (3 out of 81 years). However, the habitat mortality rate increased by 2.0 – 7.6 percent during 11 percent of the years simulated (9 out of 81 years). Similar to No Action, the survival rate of fall-run fry ranged from 48.7 – 79.3 percent throughout the simulation period. The survival rate of fall-run fry increased by 2.2 – 2.8 percent in CP1 relative to No Action during only 2 percent of the years simulated (2 out of 81 years); however, the survival rate decreased by 2.4 – 7.1 percent during 6 percent of the years simulated (5 out of 81 years).

In summary, using the 1999 - 2006 population average, CP1 resulted in little change in the average and median survival rates of fall-run Chinook salmon fry relative to No Action (average survival rate: CP1 = 56.9 percent, No Action = 57.2 percent; median survival rate CP1 = 53.9 percent, No Action = 54.0 percent). However, a significant decrease in the pre-spawning thermal mortality rate of fall-run eggs in CP1 relative to No Action during 4 critical water years and 1 dry water year resulted in an increase in the total number of fry survivors by 2,267,877 – 16,734,282 during the same 5 years. The number of fall-run fry survivors decreased by 1,100,931 – 2,702,789 in CP1 relative to No Action during five years. The average annual number of fall-run fry survivors increased by 480,086 in CP1 relative to No Action, and the median number of fry survivors increased by 36,860.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for fall-run Chinook salmon fry in CP1 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 6.5 – 51.5 percent with an average rate of 38.1 percent (median of 43.7 percent). The habitat mortality rate decreased by 2.5 – 3.5 percent in CP1 relative to No Action during 4 percent of the years simulated (3 out of 81 years). However, the habitat mortality rate increased by 2.0 – 16.1 percent during 9 percent of the years simulated (7 out of 81 years). Similar to No Action, the survival rate of fall-run fry ranged from 36.1 – 77.8 percent throughout the simulation period. The survival rate of fall-run fry increased by 2.2 –3.2 percent in CP1 relative to No Action during less than 4 percent of the years simulated (3 out of 81 years); however, the survival rate decreased by 3.3 – 15.3 percent during 7 percent of the years simulated (6 out of 81 years).

In summary, using the AFRP population goals, CP1 resulted in little change in the average and median survival rates of fall-run Chinook salmon fry relative to No Action (average survival rate: CP1 = 47.6 percent, No Action = 48.2 percent; median survival rate CP1 = 42.5 percent, No Action = 42.7 percent). However, a significant decrease in the pre-spawning thermal mortality rate of fall-run eggs in CP1 relative to No Action during 4 critical water years and 1 dry water year resulted in an increase in the total number of fry survivors by 2,513,443 – 18,292,812 during the same 5 years. The number of fall-run fry survivors decreased by 2,118,839 – 4,812,660 in CP1 relative to No Action during three years. The average annual number of fall-run fry survivors increased by 527,884 in CP1 relative to No Action, and the median number of fry survivors increased by 163,827.

CP2

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to habitat constraints (*i.e*., forced migration of fry due to flows or fish density) was the only significant source of mortality for fall-run Chinook salmon fry in CP2 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 5.2 – 36.8 percent with an average rate of 28.0 percent (median of 30.7 percent). The habitat mortality rate decreased by 2.6 percent in relative to No Action during 2 percent of the years simulated (2 out of 81 years). However, the habitat mortality rate increased by 2.2 – 9.6 percent during 16 percent of the years simulated (13 out of 81 years). Similar to No Action, the survival rate of fall-run fry ranged from 48.3 – 79.3 percent throughout the simulation period. The survival rate of fall-run fry increased by 2.3 – 2.7 percent in CP2 relative to No Action during only 2 percent of the years simulated (2 out of 81 years); however, the survival rate decreased by 2.0 – 8.9 percent during 12 percent of the years simulated (10 out of 81 years).

In summary, using the 1999 - 2006 population average, CP2 resulted in little change in the average and median survival rates of fall-run Chinook salmon fry relative to No Action (average survival rate: CP2 = 56.5 percent, No Action = 57.2 percent; median survival rate CP2 = 53.7 percent, No Action = 54.0 percent). However, a significant decrease in the pre-spawning thermal mortality rate of fall-run eggs in CP2 relative to No Action during 4 critical water years and 1 dry water year resulted in an increase in the total number of fry survivors by 2,046,901 – 13,936,565 during the same 5 years. The number of fall-run fry survivors decreased by 1,107,637 – 2,804,347 in CP2 relative to No Action during twelve years. The average annual number of fall-run fry survivors increased by 416,662 in CP2 relative to No Action, and the median number of fry survivors increased by 29,994.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for fall-run Chinook salmon fry in CP2 throughout the simulation period. The mortality rate due to habitat constraints increased slightly relative to No Action ranging from 10.9 – 51.0 percent with an average rate of 39.2 percent (median of 44.4 percent). The habitat mortality rate decreased by 2.2 percent in CP2 relative to No Action during 2 percent of the years simulated (2 out of 81 years). However, the habitat mortality rate increased by 2.2 – 15.5 percent in CP2 relative to No Action during 14 percent of the years simulated (11 out of 81 years). Similar to No Action, the survival rate of fall-run fry ranged from 36.5 – 77.5 percent throughout the simulation period. The survival rate of fall-run fry increased by 2.2 percent in CP2 relative to No Action during only 1 percent of the years simulated (1 out of 81 years);

however, the survival rate decreased by 2.2 – 19.0 percent during 12 percent of the years simulated (10 out of 81 years).

In summary, using the AFRP population goals, CP2 resulted in a slight decrease in the average and median survival rates of fall-run Chinook salmon fry relative to No Action (average survival rate: CP2 = 47.1 percent, No Action = 48.2 percent; median survival rate CP2 = 42.4 percent, No Action = 42.7 percent). However, a significant decrease in the pre-spawning thermal mortality rate of fall-run eggs in CP2 relative to No Action during 4 critical water years and 1 dry water year resulted in an increase in the total number of fry survivors by 2,204,215 – 15,864,577 during the same 5 years. The number of fall-run fry survivors decreased by 1,006,559 – 2,335,594 in CP2 relative to No Action during fourteen years. The average annual number of fall-run fry survivors increased by 564,447 in CP2 relative to No Action, and the median number of fry survivors increased by 33,634.

CP3 and CP5

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for fall-run Chinook salmon fry in CP3 and CP5 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 6.8 – 37.0 percent with an average rate of 28.3 percent (median of 31.3 percent). The habitat mortality rate decreased by 2.1 – 2.6 percent in relative to No Action during less than 4 percent of the years simulated (3 out of 81 years). However, the habitat mortality rate increased by 2.0 – 10.2 percent during 20 percent of the years simulated (16 out of 81 years). Similar to No Action, the survival rate of fall-run fry ranged from 48.4 – 77.5 percent throughout the simulation period. The survival rate of fall-run fry increased by 3.0 percent in CP3 and CP5 relative to No Action during only 1 percent of the years simulated (1 out of 81 years); however, the survival rate decreased by 2.3 – 9.3 percent during 14 percent of the years simulated (11 out of 81 years).

In summary, using the 1999 - 2006 population average, CP3 and CP5 resulted in a slight decrease in the average and median survival rates of fall-run Chinook salmon fry relative to No Action (average survival rate: CP3 and CP5 = 56.2 percent, No Action = 57.2 percent; median survival rate CP3 and CP5 = 53.6 percent, No Action = 54.0 percent). However, a significant decrease in the pre-spawning thermal mortality rate of fall-run eggs in CP3 and CP5 relative to No Action during 3 critical water years and 1 dry water year resulted in an increase in the total number of fry survivors by 4,214,659 – 15,413,869 during the same 4 years. The number of fall-run fry survivors decreased by 1,030,884 – 2,347,369 in CP3 and CP5 relative to No Action during eighteen years. The average annual number of fall-run fry survivors increased by 693,486 in CP3 and CP5 relative to No Action, but the median number of fry survivors *decreased* by 254,126.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for fall-run Chinook salmon fry in CP3 and CP5 throughout the simulation period. The mortality rate due to habitat constraints increased slightly relative to No Action ranging from 10.9 – 51.0 percent with an average rate of 39.2 percent (median of 44.4 percent). The habitat mortality rate decreased by 3.0 percent in CP3 and CP5 relative to No Action during only 1 percent of the years simulated (1 out of 81 years). However, the habitat mortality rate increased by 2.2 – 20.3 percent in CP3 and CP5 relative to No Action during 21 percent of the years simulated (17 out of 81 years). Similar to No Action, the survival rate of fall-run fry ranged from 36.7 – 72.8 percent throughout the simulation period. The survival rate of fall-run fry increased by 2.7 percent in CP3 and CP5 relative to No Action during only 1 percent of the years simulated (1 out of 81 years); however, the survival rate decreased by 2.0 – 18.6 percent during 19 percent of the years simulated (15 out of 81 years).

In summary, using the AFRP population goals, CP3 and CP5 resulted in a slight decrease in the average and median survival rates of fall-run Chinook salmon fry relative to No Action (average survival rate: CP3 and CP5 = 46.7 percent, No Action = 48.2 percent; median survival rate CP3 and CP5 = 42.5 percent, No Action = 42.7 percent). However, a significant decrease in the pre-spawning thermal mortality rate of fall-run eggs in CP3 and CP5 relative to No Action during 3 critical water years and 1 dry water year resulted in an increase in the total number of fry survivors by 4,634,359 – 20,223,978 during the same 4 years. The number of fall-run fry survivors decreased by 1,015,964 – 3,261,479 in CP3 and CP5 relative to No Action during 22 years. The average annual number of fall-run fry survivors increased by 894,528 in CP3 and CP5 relative to No Action, but the median number of fry survivors *decreased* by 164,087.

CP4

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for fall-run Chinook salmon fry in CP4 throughout the simulation period. The mortality rate due to habitat constraints increased slightly in CP4 relative to No Action and ranged from 11.3 – 37.8 percent with an average rate of 29.4 percent (median of 31.7 percent). The habitat mortality rate decreased by 2.7 percent in relative to No Action during only 1 percent of the years simulated (1 out of 81 years). However, the habitat mortality rate increased by 2.1 – 15.9 percent during 36 percent of the years simulated (29 out of 81 years). The survival rate of fall-run fry in CP4 ranged from 48.1 – 71.7 percent throughout the simulation period. The survival rate of fall-run fry increased by 2.7 percent in CP4 relative to No Action during only 1 percent of the years simulated (1 out of 81 years); however, the survival rate decreased by 2.0 – 20.4 percent during 24 percent of the years simulated (19 out of 81 years).

In summary, using the 1999 - 2006 population average, CP4 resulted in a decrease in the average and median survival rates of fall-run Chinook salmon fry relative to No Action (average survival rate: CP4 = 55.3 percent, No Action = 57.2 percent; median survival rate CP4 = 52.8 percent, No Action = 54.0 percent). However, a significant decrease in the pre-spawning thermal mortality rate of fall-run eggs in CP4 relative to No Action during 6 critical water years and 1 dry water year resulted in an increase in the total number of fry survivors by 5,915,254 – 36,337,029 during the same 7 years. The number of fall-run fry survivors decreased by 1,007,478 – 4,319,691 in CP4 relative to No Action during 21 years. The average annual number of fall-run fry survivors increased by 1,198,896 in CP4 relative to No Action, but the median number of fry survivors *decreased* by 343,195.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for fall-run Chinook salmon fry in CP4 throughout the simulation period. The mortality rate due to habitat constraints increased slightly relative to No Action ranging from 10.3 – 51.8 percent with an average rate of 40.4 percent (median of 45.2 percent). The habitat mortality rate decreased by 2.1 percent in CP4 relative to No Action during only 1 percent of the years simulated (1 out of 81 years). However, the habitat mortality rate increased by 2.0 – 34.7 percent in CP4 relative to No Action during 41 percent of the years simulated (33 out of 81 years). Similar to No Action, the survival rate of fall-run fry ranged from 36.0 – 72.7 percent throughout the simulation period. The survival rate of fall-run fry increased by 1.7 percent in CP4 relative to No Action during only 1 percent of the years simulated (1 out of 81 years); however, the survival rate decreased by 2.0 – 32.9 percent during 26 percent of the years simulated (21 out of 81 years).

In summary, using the AFRP population goals, CP4 resulted in a decrease in the average and median survival rates of fall-run Chinook salmon fry relative to No Action (average survival rate: CP4 = 45.7 percent, No Action = 48.2 percent; median survival rate CP4 = 41.4 percent, No Action = 42.7 percent). However, a significant decrease in the pre-spawning thermal mortality rate of fall-run eggs in CP4 relative to No Action during 6 critical water years and 1 dry water year resulted in an increase in the total number of fry survivors by 3,252,955 – 41,516,179 during the same 7 years. The number of fall-run fry survivors decreased by 1,097,197 – 4,537,141 in CP4 relative to No Action during 28 years. The average annual number of fall-run fry survivors increased by 1,087,977 in CP4 relative to No Action, but the median number of fry survivors *decreased* by 495,164.

Pre-smolt Mortality

The survival rates and sources of mortality of fall-run Chinook salmon pre-smolts using the 1999 – 2006 population average are illustrated in Figures B-41A-B and B-42A-E. The survival rates and sources of mortality of fall-run Chinook salmon pre-smolts using the AFRP population goals are illustrated in Figures B-43A-B and B-44A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for fall-run Chinook salmon pre-smolts in the No Action Alternative during 99 percent of the years simulated (water years 1922 – 2002). The mortality rate due to entrainment in unscreened water diversions ranged from 1.7 – 4.6 percent with an average rate of 3.1 percent (median of 3.1 percent). Mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) ranged from 0.0 – 1.8 percent with an average mortality rate of 0.4 percent (median of 0.3 percent). Thermal mortality of pre-smolts never exceeded 0.2 percent. The survival rate of fall-run pre-smolts ranged from 73.2 – 80.5 percent throughout the simulation period with an average survival rate of 77.5 percent (median of 77.8 percent). The number of fall-run pre-smolt survivors ranged from 32.8 – 37.8 million during 63 percent of the years simulated (51 out of 81 years). The number of fall-run pre-smolt survivors dropped to 3.6– 31.3 million during the remaining 37 percent of the years simulated primarily due to mortality of fall-run eggs due to superimposition, the flushing and dewatering of redds, and pre-spawning thermal mortality of eggs.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for fall-run Chinook salmon pre-smolts in the No Action Alternative during 99 percent of the years simulated (water years 1922 – 2002). The mortality rate due to entrainment in unscreened water diversions ranged from 1.7 – 4.6 percent with an average rate of 3.2 percent (median of 3.1 percent). Mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) ranged from 0.0 – 1.8 percent with an average mortality rate of 0.4 percent (median of 0.3 percent). Thermal mortality of pre-smolts never exceeded 0.3 percent. The survival rate of fall-run pre-smolts ranged from 73.1 – 81.1 percent throughout the simulation period with an average survival rate of 78.0 percent (median of 78.3 percent). The number of fall-run pre-smolt survivors ranged from 37.6 – 43.9 million during 63 percent of the years simulated (51 out of 81 years). The number of fall-run pre-smolt survivors dropped to 3.6– 35.5 million during the remaining 37 percent of the years simulated primarily due to mortality of fall-run eggs due to superimposition, the flushing and dewatering of redds, and pre-spawning thermal mortality of eggs.

CP1

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for fall-run Chinook salmon pre-smolts in CP1 during 98 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 1.6 – 4.6 percent with an average rate of 3.1 percent (median of 3.1 percent). Similar to No Action, mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) ranged from 0.0 – 2.2 percent with an average mortality rate of 0.5 percent (median of 0.4 percent). Like in No Action, the thermal mortality of pre-smolts never exceeded 0.3 percent. Similar to No Action, the survival rate of fall-run pre-smolts ranged from 73.5 – 80.6 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP1 resulted in little change in the average and median survival rates of fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP1 = 77.5 percent, No Action = 77.5 percent; median survival rate CP1 = 77.9 percent, No Action = 77.8 percent). The survival rates of fall-run pre-smolts in CP1 never differed from No Action by more than 1 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 4 critical water years and 1 dry water year, CP1 resulted in an increase in the number of pre-smolt fall-run survivors by 1,793,613 – 13,053,139 during those same 5 years. But the number of fall-run pre-smolt survivors decreased by 1,073,829 – 2,229,826 during four years. The average annual number of fall-run pre-smolt survivors increased by 367,487 in CP1 relative to No Action, and the median number of pre-smolt survivors increased by 38,537.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for fall-run Chinook salmon pre-smolts in CP1 during 98 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 1.6 – 4.6 percent with an average rate of 3.2 percent (median of 3.2 percent). Similar to No Action, mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) ranged from 0.0 – 2.0 percent with an average mortality rate of 0.5 percent (median of 0.3 percent). Like in No Action, the thermal mortality of pre-smolts never exceeded 0.4 percent. Similar to No Action, the survival rate of fall-run pre-smolts ranged from 73.5 – 81.2 percent throughout the simulation period.

In summary, using the AFRP population goals, CP1 resulted in little change in the average and median survival rates of fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP1 = 78.1 percent, No Action = 78.0 percent; median survival rate CP1 = 76.3 percent, No Action = 78.3 percent). The survival rates of fall-run pre-smolts in CP1 never differed from No Action by more than 1.6 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 4 critical water years and 1 dry water year, CP1 resulted in an increase in the number of pre-smolt fall-run survivors by 2,129,461 – 14,535,126 during those same 5 years. But the number of fall-run pre-smolt survivors decreased by 1,014,035 – 3,915,861 during six years. The average annual number of fall-run pre-smolt survivors increased by 411,701 in CP1 relative to No Action, and the median number of pre-smolt survivors increased by 71,082.

CP2

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for fall-run Chinook salmon pre-smolts in CP2 during 99 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 1.6 – 4.6 percent with an average rate of 3.1 percent (median of 3.1 percent). Similar to No Action, mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) ranged from 0.0 – 1.8 percent with an average mortality rate of 0.5 percent (median of 0.3 percent). Like in No Action, the thermal mortality of pre-smolts never exceeded 0.2 percent. Similar to No Action, the survival rate of fall-run pre-smolts ranged from 73.6 – 80.7 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP2 resulted in little change in the average and median survival rates of fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP2 = 77.5 percent, No Action = 77.5 percent; median survival rate CP2 = 77.9 percent, No Action = 77.8 percent). The survival rates of fall-run pre-smolts in CP2 never differed from No Action by more than 1.3 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 4 critical water years and 1 dry water year, CP2 resulted in an increase in the number of pre-smolt fall-run survivors by 1,500,654 – 10,861,188 during those same 5 years. But the number of fall-run pre-smolt survivors decreased by 1,005,244 – 2,167,603 during another six years. The average annual number of fall-run pre-smolt survivors increased by 326,130 in CP2 relative to No Action, but the median number of pre-smolt survivors *decreased* by 71,833.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for fall-run Chinook salmon pre-smolts in CP2 during 98 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 1.6 – 4.7 percent with an average rate of 3.2 percent (median of 3.2 percent). Similar to No Action, mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) ranged from 0.0 – 2.5 percent with an average mortality rate of 0.5 percent (median of 0.4 percent). Like in No Action, the thermal mortality of pre-smolts never exceeded 0.4 percent. Similar to No Action, the survival rate of fall-run pre-smolts ranged from 73.6 – 81.2 percent throughout the simulation period.

In summary, using the AFRP population goals, CP2 resulted in little change in the average and median survival rates of fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP2 = 78.1 percent, No Action = 78.1 percent; median survival rate CP2 = 78.5 percent, No Action = 78.3 percent). The survival rates of fall-run pre-smolts in CP2 never differed from No Action by more than 1.6 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 4 critical water years and 1 dry water year, CP2 resulted in an increase in the number of pre-smolt fall-run survivors by 1,648,329 – 12,475,800 during those same 5 years. But the number of fall-run pre-smolt survivors decreased by 1,000,502 – 1,801,325 during another nine years. The average annual number of fall-run pre-smolt survivors increased by 442,437 in CP2 relative to No Action, but the median number of pre-smolt survivors *decreased* by 53,658.

CP3 and CP5

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for fall-run Chinook salmon pre-smolts in CP3 and CP5 during 98 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 1.6 – 4.7 percent with an average rate of 3.1 percent (median of 3.1 percent). Similar to No Action, mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) ranged from 0.0 – 2.0 percent with an average mortality rate of 0.5 percent (median of 0.3 percent). Like in No Action, the thermal mortality of pre-smolts never exceeded 0.2 percent. Similar to No Action, the survival rate of fall-run pre-smolts ranged from 73.5 – 80.7 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP3 and CP5 resulted in little change in the average and median survival rates of fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP3 and CP5 = 77.6 percent, No Action = 77.5 percent; median survival rate CP3 and CP5 = 78.1 percent, No Action = 77.8 percent). The survival rates of fall-run pre-smolts in CP3 and CP5 never differed from No Action by more than 2.4 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 3 critical water years and 1 dry water year, CP3 and CP5 resulted in an increase in the number of pre-smolt fall-run survivors by 3,471,516 – 12,242,811 during those same 4 years. But the number of fall-run pre-smolt survivors decreased by 1,026,822 – 1,992,468 during another nine years. The average annual number of fall-run pre-smolt survivors increased by 576,290 in CP3 and CP5 relative to No Action, but the median number of pre-smolt survivors *decreased* by 165,136.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for fall-run Chinook salmon pre-smolts in CP3 and CP5 during 98 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 1.6 – 4.7 percent with an average rate of 3.2 percent (median of 3.2 percent). Similar to No Action, mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) ranged from 0.0 – 2.0 percent with an average mortality rate of 0.5 percent (median of 0.3 percent). Like in No Action, the thermal mortality of pre-smolts never exceeded 0.3 percent. Similar to No Action, the survival rate of fall-run pre-smolts ranged from 73.4 – 81.2 percent throughout the simulation period.

In summary, using the AFRP population goals, CP3 and CP5 resulted in little change in the average and median survival rates of fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP3 and CP5 = 78.2 percent, No Action = 78.1 percent; median survival rate CP3 and CP5 = 78.5 percent, No Action = 78.3 percent). The survival rates of fall-run pre-smolts in CP3 and CP5 never differed from No Action by more than 2.9 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 3 critical water years and 1 dry water year, CP3 and CP5 resulted in an increase in the number of pre-smolt fall-run survivors by 3,798,901 – 16,124,521 during those same 4 years. But the number of fall-run pre-smolt survivors decreased by 1,096,800 – 2,520,691 during another twelve years. The average annual number of fall-run pre-smolt survivors increased by 759,634 in CP3 and CP5 relative to No Action, but the median number of pre-smolt survivors *decreased* by 98,809.

CP4

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for fall-run Chinook salmon pre-smolts in CP4 during 95 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 1.6 – 4.6 percent with an average rate of 3.0 percent (median of 3.0 percent). Similar to No Action, mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) ranged from 0.0 – 2.4 percent with an average mortality rate of 0.5 percent (median of 0.4 percent). Like in No Action, the thermal mortality of pre-smolts never exceeded 0.2 percent. Similar to No Action, the survival rate of fall-run pre-smolts ranged from 73.8 – 80.7 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP4 resulted in little change in the average and median survival rates of fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP4 = 77.7 percent, No Action = 77.5 percent; median survival rate CP4 = 78.1 percent, No Action = 77.8 percent). The survival rate of fall-run pre-smolts in CP4 increased by 3.0 percent relative to No Action only during one year. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 6 critical water years and 1 dry water year, CP4 resulted in an increase in the number of pre-smolt fall-run survivors by 4,665,144 – 29,103,988 during those same 7 years. But the number of fall-run pre-smolt survivors decreased by 1,066,671 – 3,077,620 during another fourteen years. The average annual number of fall-run pre-smolt survivors increased by 979,423 in CP4 relative to No Action, but the median number of pre-smolt survivors *decreased* by 282,832.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the greatest source of mortality for fall-run Chinook salmon pre-smolts in CP4 during 96 percent of the years simulated (water years 1922 – 2002). Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 1.6 – 4.6 percent with an average rate of 3.1 percent (median of 3.1 percent). Similar to No Action, mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) ranged from 0.0 – 2.0 percent with an average mortality rate of 0.5 percent (median of 0.4 percent). Like in No Action, the thermal mortality of pre-smolts never exceeded 0.2 percent. Similar to No Action, the survival rate of fall-run pre-smolts ranged from 73.8 – 81.2 percent throughout the simulation period.

In summary, using the AFRP population goals, CP4 resulted in little change in the average and median survival rates of fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP4 = 78.2 percent, No Action = 78.1 percent; median survival rate CP4 = 78.6 percent, No Action = 78.3 percent). The survival rates of fall-run pre-smolts in CP4 increased by 2.0 – 3.3 percent relative to No Action during 4 percent of the years simulated (3 out of 81 years). Due to a decrease in pre-spawning thermal mortality of fall-run eggs during 6 critical water years and 1 dry water year, CP4 resulted in an increase in the number of pre-smolt fall-run survivors by 2,734,190 – 33,469,020 during those same 7 years. But the number of fall-run pre-smolt survivors decreased by 1,002,068 – 2,842,064 during another 23 years. The average annual number of fall-run pre-smolt survivors increased by 900,335 in CP4 relative to No Action, but the median number of pre-smolt survivors *decreased* by 403,495.

Immature Smolt Mortality

The survival rates and sources of mortality of fall-run Chinook salmon immature smolts using the 1999 – 2006 population average are illustrated in Figures B-45A-B and B-46A-E. The survival rates and sources of mortality of fall-run Chinook salmon immature smolts using the AFRP population goals are illustrated in Figures B-47A-B and B-48A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for fall-run Chinook salmon immature smolts in the No Action Alternative. The mortality rate due to entrainment in unscreened water diversions ranged from 0.2 – 1.7 percent with an average rate of 0.7 percent (median of 0.7 percent). The survival rate of fall-run immature smolts ranged from 94.4 – 99.6 percent throughout the simulation period with an average survival rate of 97.7 percent (median of 98.0 percent). However, Salmod likely overestimates the survival rate of fall-run immature smolts by limiting the simulation to areas upstream of the Red Bluff Diversion Dam. The number of fall-run immature smolt survivors ranged from 30.1 – 36.7 million during 68 percent of the years simulated (55 out of 81 years). The number of fall-run immature smolt survivors dropped to 3.4 – 28.8 million during the remaining 32 percent of the years simulated primarily due to mortality of fall-run eggs due to superimposition, the flushing and dewatering of redds, and pre-spawning thermal mortality of eggs.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the only other significant source of mortality for fall-run Chinook salmon immature smolts in the No Action Alternative. The mortality rate due to entrainment in unscreened water diversions ranged from 0.1 – 1.6 percent with an average rate of 0.7 percent (median of 0.6 percent). The survival rate of fall-run immature smolts ranged from 94.6 – 99.7 percent throughout the simulation period with an average survival rate of 97.9 percent (median of 98.2 percent). The number of fall-run immature smolt survivors ranged from 37.1 – 42.7 million during 63 percent of the years simulated (51 out of 81 years). The number of fall-run immature smolt survivors dropped to 3.4 – 34.9 million during the remaining 37 percent of the years simulated primarily due to mortality of fall-run eggs due to superimposition, the flushing and dewatering of redds, and pre-spawning thermal mortality of eggs.

CP1

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was only significant source of mortality for fall-run Chinook salmon immature smolts in CP1. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.2 – 1.7 percent with an average rate of 0.7 percent (median of 0.7 percent). Like in No Action, the survival rate of fall-run immature smolts ranged from 94.1 – 99.6 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP1 resulted in little change in the average and median survival rates of fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP1 = 97.7 percent, No Action = 97.7 percent; median survival rate CP1 = 97.9 percent, No Action = 98.0 percent). The survival rates of fall-run immature smolts in CP1 never differed from No Action by more than 1.1 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 4 critical water years and 1 dry water year, CP1 resulted in an increase in the number of immature smolt fall-run survivors by 1,736,636 – 12,760,023 during those same 5 years. But the number of fall-run pre-smolt survivors decreased by 1,024,751 – 2,264,354 during another four years. The average annual number of fall-run immature smolt survivors increased by 337,390 in CP1 relative to No Action, and the median number of immature smolt survivors increased by 47,582.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was only significant source of mortality for fall-run Chinook salmon immature smolts in CP1. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.2 – 1.7 percent with an average rate of 0.7 percent (median of 0.6 percent). Like in No Action, the survival rate of fall-run immature smolts ranged from 94.3 – 99.6 percent throughout the simulation period.

In summary, using the AFRP population goals, CP1 resulted in little change in the average and median survival rates of fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP1 = 97.9 percent, No Action = 97.9 percent; median survival rate CP1 = 98.0 percent, No Action = 98.2 percent). The survival rates of fall-run immature smolts in CP1 never differed from No Action by more than 0.9 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 4 critical water years and 1 dry water year, CP1 resulted in an increase in the number of immature smolt fall-run survivors by 2,011,723 – 14,245,742 during those same 5 years. But the number of fall-run pre-smolt survivors decreased by 1,016,184 – 3,949,708 during another eight years. The average annual number of fall-run immature smolt survivors increased by 384,015 in CP1 relative to No Action, and the median number of immature smolt survivors increased by 67,221.

CP2

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was only significant source of mortality for fall-run Chinook salmon immature smolts in CP2. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.2 – 1.7 percent with an average rate of 0.7 percent (median of 0.7 percent). Like in No Action, the survival rate of fall-run immature smolts ranged from 94.1 – 99.6 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP2 resulted in little change in the average and median survival rates of fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP2 = 97.7 percent, No Action = 97.7 percent; median survival rate CP2 = 98.0 percent, No Action = 98.0 percent). The survival rates of fall-run immature smolts in CP2 never differed from No Action by more than 1.1 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 4 critical water years and 1 dry water year, CP2 resulted in an increase in the number of immature smolt fall-run survivors by 1,484,436 – 10,588,754 during those same 5 years. But the number of fall-run immature smolt survivors decreased by 1,114,622 – 2,114,152 during another four years. The average annual number of fall-run immature smolt survivors increased by 303,490 in CP2 relative to No Action, but the median number of immature smolt survivors *decreased* by 37,982.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was only significant source of mortality for fall-run Chinook salmon immature smolts in CP2. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.2 – 1.7 percent with an average rate of 0.7 percent (median of 0.6 percent). Like in No Action, the survival rate of fall-run immature smolts ranged from 94.2 – 99.6 percent throughout the simulation period.

In summary, using the AFRP population goals, CP2 resulted in little change in the average and median survival rates of fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP2 = 97.9 percent, No Action = 97.9 percent; median survival rate CP2 = 98.1 percent, No Action = 98.2 percent). The survival rates of fall-run immature smolts in CP2 never differed from No Action by more than 0.9 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 4 critical water years and 1 dry water year, CP2 resulted in an increase in the number of immature smolt fall-run survivors by 1,634,795 – 12,215,075 during those same 5 years. But the number of fall-run immature smolt survivors decreased by 1,006,906 – 1,711,996 during another ten years. The average annual number of fall-run immature smolt survivors increased by 424,577 in CP2 relative to No Action, but the median number of immature smolt survivors *decreased* by 34,523.

CP3 and CP5

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was only significant source of mortality for fall-run Chinook salmon immature smolts in CP3 and CP5. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.2 – 1.9 percent with an average rate of 0.7 percent (median of 0.7 percent). Like in No Action, the survival rate of fall-run immature smolts ranged from 94.3 – 99.6 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP3 and CP5 resulted in little change in the average and median survival rates of fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP3 and CP5 = 97.8 percent, No Action = 97.7 percent; median survival rate CP3 and CP5 = 98.1 percent, No Action = 98.0 percent). The survival rates of fall-run immature smolts in CP3 and CP5 never differed from No Action by more than 1.6 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 3 critical water years and 1 dry water year, CP3 and CP5 resulted in an increase in the number of immature smolt fall-run survivors by 3,304,749 – 11,915,632 during those same 4 years. But the number of fall-run immature smolt survivors decreased by 1,014,813 – 1,767,601 during another eight years. The average annual number of fall-run immature smolt survivors increased by 566,413 in CP3 and CP5 relative to No Action, but the median number of immature smolt survivors *decreased* by 166,884.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was only significant source of mortality for fall-run Chinook salmon immature smolts in CP3 and CP5. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.1 – 1.8 percent with an average rate of 0.7 percent (median of 0.6 percent). Like in No Action, the survival rate of fall-run immature smolts ranged from 94.3 – 99.7 percent throughout the simulation period.

In summary, using the AFRP population goals, CP3 and CP5 resulted in little change in the average and median survival rates of fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP3 and CP5 = 98.0 percent, No Action = 97.9 percent; median survival rate CP3 and CP5 = 98.3 percent, No Action = 98.2 percent). The survival rates of fall-run immature smolts in CP3 and CP5 never differed from No Action by more than 1.4 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 4 critical water years and 1 dry water year, CP3 and CP5 resulted in an increase in the number of immature smolt fall-run survivors by 1,198,010 – 15,746,095 during those same 5 years. But the number of fall-run immature smolt survivors decreased by 1,000,785 – 2,474,455 during another thirteen years. The average annual number of fall-run immature smolt survivors increased by 754,846 in CP3 and CP5 relative to No Action, but the median number of immature smolt survivors *decreased* by 108,029.

CP4

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was only significant source of mortality for fall-run Chinook salmon immature smolts in CP4. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.2 – 1.8 percent with an average rate of 0.8 percent (median of 0.7 percent). Like in No Action, the survival rate of fall-run immature smolts ranged from 94.0 – 99.6 percent throughout the simulation period.

In summary, using the 1999 - 2006 population average, CP4 resulted in little change in the average and median survival rates of fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP4 = 97.6 percent, No Action = 97.7 percent; median survival rate CP4 = 97.8 percent, No Action = 98.0 percent). The survival rates of fall-run immature smolts in CP4 never differed from No Action by more than 2.0 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 6 critical water years and 1 dry water year, CP4 resulted in an increase in the number of immature smolt fall-run survivors by 4,470,408 – 28,278,743 during those same 7 years. But the number of fall-run immature smolt survivors decreased by 1,055,527 – 2,887,595 during another fourteen years. The average annual number of fall-run immature smolt survivors increased by 909,170 in CP4 relative to No Action, but the median number of immature smolt survivors *decreased* by 305,739.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was only significant source of mortality for fall-run Chinook salmon immature smolts in CP4. Similar to No Action, the mortality rate due to entrainment in unscreened water diversions ranged from 0.2 – 1.7 percent with an average rate of 0.7 percent (median of 0.6 percent). Like in No Action, the survival rate of fall-run immature smolts ranged from 94.2 – 99.6 percent throughout the simulation period.

In summary, using the AFRP population goals, CP4 resulted in little change in the average and median survival rates of fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP4 = 97.8 percent, No Action = 97.9 percent; median survival rate CP4 = 98.1 percent, No Action = 98.2 percent). The survival rates of fall-run immature smolts in CP4 never differed from No Action by more than 1.6 percent. However, due to a decrease in pre-spawning thermal mortality of fall-run eggs during 6 critical water years and 1 dry water year, CP4 resulted in an increase in the number of immature smolt fall-run survivors by 2,526,576 – 32,590,383 during those same 7 years. But the number of fall-run immature smolt survivors decreased by 1,016,214 – 2,538,660 during another 22 years. The average annual number of fall-run immature smolt survivors increased by 838,201 in CP4 relative to No Action, but the median number of immature smolt survivors *decreased* by 440,796.

Late Fall-run Chinook Salmon

Egg Mortality

The survival rates and sources of mortality of late fall-run Chinook salmon eggs using the 1999 – 2006 population average are illustrated in Figures B-49A-D and B-50A-E. The survival rates and sources of mortality of late fall-run Chinook salmon eggs using the AFRP population goals are illustrated in Figures B-51A-D and B-52A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) were the greatest sources of mortality for late fall-run Chinook salmon eggs in the No Action Alternative during most years simulated. The superimposition mortality rate ranged from 0.0 – 22.2 percent with an average rate of 3.4 percent (median of 0.0 percent). Superimposition mortality was significant (greater than 2 percent) during 24 percent of the years simulated (19 out of 80 years). However, Salmod likely underestimates the superimposition mortality rate for late fall-run Chinook salmon due to the model's inability to simulate competition for spawning sites with fall-run and spring-run Chinook salmon. The incubation mortality rate ranged from 0.1 – 50.0 percent with an average rate of 2.7 percent (median of 0.7 percent). Incubation mortality was significant (greater than 2 percent) during 18 percent of the years simulated (14 out of 80 years). Pre-spawning thermal mortality was insignificant in all years. Thermal mortality of eggs while in the redd never exceeded 0.7 percent. The survival rate of late fall-run eggs ranged from 40.8 – 57.9 percent during 90 percent of the years simulated (72 out of 80 years) but was reduced to 14.9 – 37.7 percent during the remaining 10 percent of the years. The number of late fall-run eggs surviving exceeded 13 million during 90 percent of the years simulated.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) were the greatest sources of mortality for late fall-run Chinook salmon eggs in the No Action Alternative during most years simulated. The superimposition mortality rate ranged from 0.0 – 43.3 percent with an average rate of 10.4 percent (median of 0.7 percent). Superimposition mortality was significant (greater than 2 percent) during 48 percent of the years simulated (38 out of 80 years). However, Salmod likely underestimates the superimposition mortality rate for late fall-run Chinook salmon due to the model's inability to simulate competition for spawning sites with fall-run and spring-run Chinook salmon. The incubation mortality rate ranged from 0.1 – 38.7 percent with an average rate of 2.4 percent (median of 0.7 percent). Incubation mortality was significant (greater than 2 percent) during 16 percent of the years simulated (13 out of 80 years). Pre-spawning thermal mortality was insignificant in all years. Thermal mortality of eggs while in the redd never exceeded 0.8 percent. The survival rate of late fall-run eggs ranged from 40.7 – 57.6 percent during 70 percent of the years simulated (56 out of 80 years) but was reduced to 9.8 – 39.5 percent during the remaining 30 percent of the years. The number of late fall-run eggs surviving exceeded 30 million during 61 percent of the years simulated.

CP1

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for late fall-run Chinook salmon eggs in CP1 during most years simulated. The superimposition mortality rate was similar to No Action ranging from 0.0 – 22.2 percent with an average rate of 3.2 percent (compared to 3.4 percent in No Action). Superimposition mortality in CP1 was significant (greater than 2 percent) during 21 percent of the years simulated (17 out of 80 years) compared to 24 percent of the years (19 out of 80 years) in No Action. Superimposition mortality decreased significantly in CP1 relative to No Action by 3.3 – 8.4 percent only during 3 years (dry water years 1926 and 1939; wet water year 1927) which represented less than 4 percent of the years simulated. As stated previously, Salmod likely underestimates the superimposition mortality rate for late fall-run Chinook salmon due to the model's inability to simulate competition for spawning sites with fall-run and spring-run Chinook salmon. The incubation mortality rate was similar to No Action ranging from 0.1 – 50.0 percent with an average rate of 2.7 percent (median of 0.8 percent). Like in No Action, incubation mortality was significant (greater than 2 percent) in CP1 during 18 percent of the years simulated (14 out of 80 years). Incubation mortality decreased by 1.1 – 2.0 percent in CP1 relative to No Action only during the dry water years 1926 and 1985. Pre-spawning thermal mortality was insignificant in all years in CP1 as in No Action. Thermal mortality of eggs while in the redd never exceeded 1.1 percent in CP1.

In summary, using the 1999 - 2006 population average, the survival rate of late fall-run eggs in CP1 increased significantly (greater than 2 percent) relative to No Action by 3.3 – 8.4 percent only during 3 years (1926, 1927, and 1939); this increase in the survival rate occurred in less than 4 percent of the years simulated. The average annual number of late fall-run egg survivors increased by 115,353 in CP1 relative to No Action, and the median number of eggs survivors increased by 69,043.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for late fall-run Chinook salmon eggs in CP1 during most years simulated. The superimposition mortality rate in CP1 was 0.0 – 43.3 percent with an average rate of 10.1 percent (compared to 10.4 percent in No Action). Like in No Action, the superimposition mortality in CP1 was significant (greater than 2 percent) during 48 percent of the years simulated (38 out of 80 years). Superimposition mortality decreased significantly in CP1 relative to No Action by 4.1 – 12.4 percent during 5 years (critical water year 1977; dry water years 1926 and 1939; below normal water year 1962; and wet water year 1927) which represented 6 percent of the years simulated. However, superimposition mortality increased by 10.5 percent relative to No Action during the wet water year 1975. As stated previously, Salmod likely underestimates the superimposition mortality rate for late fall-run Chinook salmon due to the model's inability to simulate competition for spawning sites with fall-run and spring-run Chinook salmon. The incubation mortality rate was similar to No Action ranging from 0.1 – 38.7 percent with an average rate of 2.4 percent (median of 0.8 percent). Like in No Action, incubation mortality was significant (greater than 2 percent) in CP1 during 16 percent of the years simulated (13 out of 80 years). Incubation mortality decreased by 1.1 – 1.9 percent in CP1 relative to No Action only during the dry water years 1926 and 1985. Pre-spawning thermal mortality was insignificant in all years in CP1 as in No Action. Thermal mortality of eggs while in the redd never exceeded 1.1 percent in CP1.

In summary, using the AFRP population goals, the survival rate of late fall-run eggs in CP1 increased significantly (greater than 2 percent) relative to No Action by 2.6 – 8.5 percent only during 5 years (1926, 1927, 1939, 1962, and 1977) which represented 6 percent of the years simulated. However, the survival rate decreased by 5.9 percent relative to No Action during the wet water year 1975 due to a significant increase in superimposition mortality that year. The average annual number of late fall-run egg survivors increased by 270,000 in CP1 relative to No Action, and the median number of eggs survivors increased by 137,141.

CP2

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for late fall-run Chinook salmon eggs in CP2 during most years simulated. The superimposition mortality rate in CP2 ranged from 0.0 – 22.2 percent with an average rate of 3.1 percent (compared to 3.4 percent in No Action). Superimposition mortality in CP2 was significant (greater than 2 percent) during 20 percent of the years simulated (16 out of 80 years) compared to 24 percent of the years (19 out of 80 years) in No Action. Superimposition mortality decreased significantly in CP2 relative to No Action by 3.5 – 11.0 percent only during 3 years (dry water years 1926 and 1939; wet water year 1927) which represented less than 4 percent of the years simulated. As stated previously, Salmod likely underestimates the superimposition mortality rate for late fall-run Chinook salmon due to the model's inability to simulate competition for spawning sites with fall-run and spring-run Chinook salmon. The incubation mortality rate was similar to No Action ranging from 0.1 – 50.0 percent with an average rate of 2.6 percent (median of 0.8 percent). Like in No Action, incubation mortality was significant (greater than 2 percent) in CP2 during 18 percent of the years simulated (14 out of 80 years). Incubation mortality decreased by 1.1 – 3.4 percent in CP2 relative to No Action only during the dry water years 1926, 1939, and 1985. Pre-spawning thermal mortality was insignificant in all years in CP2 as in No Action. Thermal mortality of eggs while in the redd never exceeded 1.0 percent in CP2.

In summary, using the 1999 - 2006 population average, the survival rate of late fall-run eggs in CP2 increased significantly (greater than 2 percent) relative to No Action by 2.0 – 7.3 percent only during 4 years (1926, 1927, 1939, and 1985); this increase in the survival rate occurred in only 5 percent of the years simulated. The average annual number of late fall-run egg survivors increased by 154,158 in CP2 relative to No Action, and the median number of eggs survivors increased by 78,591.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for late fall-run Chinook salmon eggs in CP2 during most years simulated. The superimposition mortality rate in CP2 ranged from 0.0 – 43.3 percent with an average rate of 9.9 percent (compared to 10.4 percent in No Action). Superimposition mortality in CP2 was significant (greater than 2 percent) during 48 percent of the years simulated (38 out of 80 years) like in No Action. Superimposition mortality decreased significantly in CP2 relative to No Action by 5.0 – 15.1 percent during 5 years (critical water year 1977; dry water years 1926 and 1939; below normal water year 1962; and wet water year 1927) which represents 6 percent of the years simulated. However, the superimposition mortality rate increased by 7.6 percent during the critical water year 1976 relative to No Action. As stated previously, Salmod likely underestimates the superimposition mortality rate for late fall-run Chinook salmon due to the model's inability to simulate competition for spawning sites with fall-run and spring-run Chinook salmon. The incubation mortality rate was similar to No Action ranging from 0.1 – 38.7 percent with an average rate of 2.3 percent (median of 0.8 percent). Like in No Action, incubation mortality was significant (greater than 2 percent) in CP2 during 16 percent of the years simulated (13 out of 80 years). Incubation mortality decreased by 1.1 – 3.2 percent in CP2 relative to No Action only during the dry water years 1926, 1939, and 1985. Pre-spawning thermal mortality was insignificant in all years in CP2 as in No Action. Thermal mortality of eggs while in the redd never exceeded 1.1 percent in CP2.

In summary, using the AFRP population goals, the survival rate of late fall-run eggs in CP2 increased significantly (greater than 2 percent) relative to No Action by 3.3 – 9.9 percent only during 5 years (1926, 1927, 1939, 1962, and 1977); this increase in the survival rate occurred in only 6 percent of the years simulated. However, the survival rate decreased by 4.3 percent relative to No Action during the critical water year 1976. The average annual number of late fall-run egg survivors increased by 417,393 in CP2 relative to No Action, and the median number of eggs survivors increased by 162,131.

CP3 and CP5

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for late fall-run Chinook salmon eggs in CP3 and CP5 during most years simulated. The superimposition mortality rate in CP3 and CP5 ranged from 0.0 – 22.2 percent with an average rate of 3.1 percent (compared to 3.4 percent in No Action). Superimposition mortality in CP3 and CP5 was significant (greater than 2 percent) during 21 percent of the years simulated (17 out of 80 years) compared to 24 percent of the years (19 out of 80 years) in No Action. Superimposition mortality decreased significantly in CP3 and CP5 relative to No Action by 8.2 - 12.5 percent only during 2 years (dry water years 1926 and 1939) which represented less than 3 percent of the years simulated. As stated previously, Salmod likely underestimates the superimposition mortality rate for late fall-run Chinook salmon due to the model's inability to simulate competition for spawning sites with fall-run and spring-run Chinook salmon. The incubation mortality rate was similar to No Action ranging from 0.1 – 50.0 percent with an average rate of 2.6 percent (median of 0.8 percent). Incubation mortality was significant (greater than 2 percent) in CP3 and CP5 during 16 percent of the years simulated

(13 out of 80 years) compared to 18 percent (14 out of 80 years) in No Action, CP1, and CP2. Incubation mortality decreased by 2.0 – 4.9 percent in CP3 and CP5 relative to No Action only during the dry water years 1926, 1939, and 1985. Pre-spawning thermal mortality was insignificant in all years in CP3 and CP5 as in No Action. Thermal mortality of eggs while in the redd never exceeded 1.0 percent in CP3 and CP5.

In summary, using the 1999 - 2006 population average, the survival rate of late fall-run eggs in CP3 and CP5 increased significantly (greater than 2 percent) relative to No Action by 3.4 – 10.1 percent only during 3 years (dry water years 1926, 1939, and 1985); this increase in the survival rate occurred in less than 4 percent of the years simulated. The average annual number of late fall-run egg survivors increased by 168,648 in CP3 and CP5 relative to No Action, and the median number of eggs survivors increased by 83,546.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for late fall-run Chinook salmon eggs in CP3 and CP5 during most years simulated. The superimposition mortality rate in CP3 and CP5 ranged from 0.0 – 43.2 percent with an average rate of 9.9 percent (compared to 10.4 percent in No Action). Superimposition mortality in CP3 and CP5 was significant (greater than 2 percent) during 46 percent of the years simulated (37 out of 80 years) compared to 48 percent of the years in No Action (38 out of 80 years). Superimposition mortality decreased significantly in CP3 and CP5 relative to No Action by 5.1 – 28.0 percent during 3 years (critical water year 1977 and dry water years 1926 and 1939) which represents less than 4 percent of the years simulated. However, the superimposition mortality rate increased by 9.3 percent during the critical water year 1976 relative to No Action. As stated previously, Salmod likely underestimates the superimposition mortality rate for late fall-run Chinook salmon due to the model's inability to simulate competition for spawning sites with fall-run and spring-run Chinook salmon. The incubation mortality rate was similar to No Action ranging from 0.1 – 38.7 percent with an average rate of 2.3 percent (median of 0.7 percent). Incubation mortality was significant (greater than 2 percent) in CP3 and CP5 during 15 percent of the years simulated (12 out of 80 years) compared to 16 percent of the years in No Action (13 out of 80 years). Incubation mortality decreased by 2.1 – 4.8 percent in CP3 and CP5 relative to No Action only during the dry water years 1926, 1939, and 1985. Pre-spawning thermal mortality was insignificant in all years in CP3 and CP5 as in No Action. Thermal mortality of eggs while in the redd never exceeded 1.0 percent in CP3 and CP5.

In summary, using the AFRP population goals, the survival rate of late fall-run eggs in CP3 and CP5 increased significantly (greater than 2 percent) relative to No Action by 2.5 – 19.0 percent only during 4 years (1926, 1939, 1977, and 1985); this increase in the survival rate occurred in only 5 percent of the years simulated. In addition, the survival rate decreased by 5.4 percent relative to No Action during the critical water year 1976. The average annual number of late fall-run egg survivors increased by 437,206 in CP3 and CP5 relative to No Action, and the median number of eggs survivors increased by 181,878.

CP4

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for late fall-run Chinook salmon eggs in CP4 during most years simulated. The superimposition mortality rate in CP4 ranged from 0.0 – 22.2 percent with an average rate of 3.2 percent (compared to 3.4 percent in No Action). Superimposition mortality in CP4 was significant (greater than 2 percent) during 21 percent of the years simulated (17 out of 80 years) compared to 24 percent of the years (19 out of 80 years) in No Action. Superimposition mortality decreased significantly in CP4 relative to No Action by 3.3 - 8.4 percent during only 3 years (dry water years 1926 and 1939 and wet water year 1927) which represented less than 4 percent of the years simulated. As stated previously, Salmod likely underestimates the superimposition mortality rate for late fall-run Chinook salmon due to the model's inability to simulate competition for spawning sites with fall-run and spring-run Chinook salmon. The incubation mortality rate was similar to No Action ranging from 0.1 – 50.0 percent with an average rate of 2.7 percent (median of 0.8 percent). Like in No Action, incubation mortality was significant (greater than 2 percent) in CP4 during 18 percent of the years simulated (14 out of 80 years). Incubation mortality decreased by 1.1 – 2.0 percent in CP4 relative to No Action only during the dry water years 1926 and 1985. Pre-spawning thermal mortality was insignificant in all years in CP4 as in No Action. Thermal mortality of eggs while in the redd never exceeded 1.2 percent in CP4.

In summary, using the 1999 - 2006 population average, the survival rate of late fall-run eggs in CP4 increased significantly (greater than 2 percent) relative to No Action by 2.2 – 6.0 percent during 4 years (dry water years 1926 and 1939; above normal water year 1922; and wet water year 1927); this increase in the survival rate occurred in 5 percent of the years simulated. The average annual number of late fall-run egg survivors increased by 285,693 in CP4 relative to No Action, and the median number of eggs survivors increased by 238,967.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc*.), mortality due to superimposition and to the flushing or dewatering of redds (incubation mortality) continued to be the greatest sources of mortality for late fall-run Chinook salmon eggs in CP4 during most years simulated. The superimposition mortality rate in CP3 and CP5 ranged from 0.0 – 43.3 percent with an average rate of 10.1 percent (compared to 10.4 percent in No Action). Like in No Action, CP1, and CP2, superimposition mortality in CP4 was significant (greater than 2 percent) during 48 percent of the years simulated (38 out of 80 years). Superimposition mortality decreased significantly in CP4 relative to No Action by 4.1 - 12.4 percent during 5 years (critical water year 1977; dry water years 1926 and 1939; below normal water year 1962; and wet water year 1927) which represented only 6 percent of the years simulated. Superimposition mortality increased by 10.5 percent relative to No Action during the wet water year 1975. As stated previously, Salmod likely underestimates the superimposition mortality rate for late fall-run Chinook salmon due to the model's inability to simulate competition for spawning sites with fall-run and spring-run Chinook salmon. The incubation mortality rate was similar to No Action ranging from 0.1 – 38.7 percent with an average rate of 2.4 percent (median of 0.8 percent).

Like in No Action, CP1, and CP2, incubation mortality was significant (greater than 2 percent) in CP4 during 16 percent of the years simulated (13 out of 80 years). Incubation mortality decreased by 1.9 percent in CP4 relative to No Action only during the dry water year 1985. Pre-spawning thermal mortality was insignificant in all years in CP4 as in No Action. Thermal mortality of eggs while in the redd never exceeded 1.3 percent in CP4.

In summary, using the AFRP population goals, the survival rate of late fall-run eggs in CP4 increased significantly (greater than 2 percent) relative to No Action by 2.1 – 9.0 percent during 6 years (1922, 1926, 1927, 1939, 1962, and 1977); this increase in the survival rate occurred in less than 8 percent of the years simulated. However, the survival rate decreased by 5.3 percent relative to No Action during the wet water year 1975. The average annual number of late fall-run egg survivors increased by 600,809 in CP4 relative to No Action, and the median number of eggs survivors increased by 512,342.

Fry Mortality

The survival rates and sources of mortality of late fall-run Chinook salmon fry using the 1999 – 2006 population average are illustrated in Figures B-53A-C and B-54A-E. The survival rates and sources of mortality of late fall-run Chinook salmon fry using the AFRP population goals are illustrated in Figures B-55A-C and B-56A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for late fall-run Chinook salmon fry in the No Action Alternative throughout the simulation period. The mortality rate due to habitat constraints ranged from 3.8 – 26.3 percent with an average rate of 20.5 percent (median of 22.0 percent). However, Salmod likely underestimates the mortality of late fall-run fry caused by habitat constraints due to the model's inability to simulate resource competition among the four runs of Chinook salmon and steelhead. The survival rate of late fall-run fry ranged from 60.1 – 81.1 percent throughout the simulation period with an average rate of 65.2 percent (median of 63.8 percent). The number of late fall-run fry survivors ranged from 8,139,763 – 11,941,509 during 96 percent of the years simulated (77 out of 80 years). The number of late fall-run fry survivors dropped to 3,979,188 – 6,223,058 during the remaining 4 percent of the years simulated primarily due to the mortality of late fall-run eggs from superimposition and the flushing or dewatering of redds.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for late fall-run Chinook salmon fry in the No Action Alternative throughout the simulation period. The mortality rate due to habitat constraints ranged from 4.1 – 42.2 percent with an average rate of 27.6 percent (median of 33.1 percent). However, Salmod likely underestimates the mortality of late fall-run fry caused by habitat constraints due to the model's inability to simulate resource competition among the four runs of Chinook salmon and steelhead. The survival rate of late fall-run fry ranged from 46.8 – 80.8 percent throughout the simulation period with an average rate of 59.1 percent (median of 54.3 percent). The number of late fall-run fry survivors ranged from 12,339,091 – 20,493,707 during 96 percent of the years simulated (77 out of 80 years). The number of late fall-run fry survivors dropped to 5,391,781 – 8,524,774 during the remaining 4 percent of the years simulated primarily due to the mortality of late fall-run eggs from superimposition and the flushing or dewatering of redds.

CP1

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for late fall-run Chinook salmon fry in CP1 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 4.4 – 27.2 percent with an average rate of 20.7 percent (median of 22.3 percent). The habitat mortality rate decreased by 2.0 – 2.8 percent in CP1 relative to No Action during 9 percent of the years simulated (7 out of 80 years). However, the habitat mortality rate increased by 2.0 – 7.0 percent during 13 percent of the years simulated (10 out of 80 years). Similar to No Action, the survival rate of late fall-run fry ranged from 60.5– 80.6 percent throughout the simulation period. The survival rate of late fall-run fry increased by 2.1 – 2.2 percent in CP1 relative to No Action during only 3 percent of the years simulated (2 out of 80 years); however, the survival rate decreased by 2.0 – 6.1 percent during 6 percent of the years simulated (5 out of 80 years).

In summary, using the 1999 - 2006 population average, CP1 resulted in little change in the average and median survival rates of late fall-run Chinook salmon fry relative to No Action (average survival rate: CP1 = 65.0 percent, No Action = 65.2 percent; median survival rate CP1 = 63.5 percent, No Action = 63.8 percent). CP1 resulted in an increase in the average number of late fall-run fry by 50,082 relative to No Action and an increase in the median number of late fall-run fry survivors by 23,246.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for late fall-run Chinook salmon fry in CP1 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 4.7 – 44.2 percent with an average rate of 28.1 percent (median of 32.7 percent). The habitat mortality rate decreased by 2.0 – 7.6 percent in CP1 relative to No Action during 6 percent of the years simulated (5 out of 80 years). However, the habitat mortality rate increased by 2.0 – 10.4 percent during 14 percent of the years simulated (11 out of 80 years). Similar to No Action, the survival rate of late fall-run fry ranged from 45.4 – 80.2 percent throughout the simulation period. The survival rate of late fall-run fry increased by 2.4 – 6.5 percent in CP1 relative to No Action during only 3 percent of the years simulated (2 out of 80 years); however, the survival rate decreased by 2.0 – 9.2 percent during 9 percent of the years simulated (7 out of 80 years).

In summary, using the AFRP population goals, CP1 resulted in little change in the average and median survival rates of late fall-run Chinook salmon fry relative to No Action (average survival rate: CP1 = 58.6 percent, No Action = 59.1 percent; median survival rate CP1 = 54.6 percent, No Action = 54.3 percent). CP1 resulted in an increase in the average annual number of late fall-run fry by 46,616 relative to No Action and an increase in the median number of late fall-run fry survivors by 9,676.

CP2

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for late fall-run Chinook salmon fry in CP2 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 4.3 – 27.4 percent with an average rate of 20.9 percent (median of 22.7 percent). The habitat mortality rate decreased by 2.1 – 3.9 percent in CP2 relative to No Action during 11 percent of the years simulated (9 out of 80 years). However, the habitat mortality rate increased by 2.1 – 8.1 percent during 16 percent of the years simulated (13 out of 80 years). Similar to No Action, the survival rate of late fall-run fry ranged from 60.4– 80.7 percent throughout the simulation period. The survival rate of late fall-run fry increased by 2.0 – 3.0 percent in CP2 relative to No Action during only 5 percent of the years simulated (4 out of 80 years); however, the survival rate decreased by 2.0 – 7.3 percent during 13 percent of the years simulated (10 out of 80 years).

In summary, using the 1999 - 2006 population average, CP2 resulted in little change in the average and median survival rates of late fall-run Chinook salmon fry relative to No Action (average survival rate: CP2 = 64.9 percent, No Action = 65.2 percent; median survival rate CP2 = 63.3 percent, No Action = 63.8 percent). CP2 resulted in an increase in the average number of late fall-run fry by 48,825 relative to No Action and an increase in the median number of late fall-run fry survivors by 38,928.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for late fall-run Chinook salmon fry in CP2 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 4.1 – 44.5 percent with an average rate of 28.4 percent (median of 33.0 percent). The habitat mortality rate decreased by 2.2 – 5.0 percent in CP2 relative to No Action during 6 percent of the years simulated (5 out of 80 years). However, the habitat mortality rate increased by 2.0 – 13.2 percent during 16 percent of the years simulated (13 out of 80 years). Similar to No Action, the survival rate of late fall-run fry ranged from 45.2 – 80.8 percent throughout the simulation period. The survival rate of late fall-run fry increased by 2.2 – 4.6 percent in CP2 relative to No Action during only 4 percent of the years simulated (3 out of 80 years); however, the survival rate decreased by 2.1 – 11.4 percent during 10 percent of the years simulated (8 out of 80 years).

In summary, using the AFRP population goals, CP2 resulted in little change in the average and median survival rates of late fall-run Chinook salmon fry relative to No Action (average survival rate: CP2 = 58.4 percent, No Action = 59.1 percent; median survival rate CP2 = 54.1 percent, No Action = 54.3 percent). CP2 resulted in an increase in the average annual number of late fall-run fry by 43,068 relative to No Action and an increase in the median number of late fall-run fry survivors by 4,574.

CP3 and CP5

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for late fall-run Chinook salmon fry in CP3 and CP5 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 4.4 – 27.5 percent with an average rate of 20.8 percent (median of 22.4 percent). The habitat mortality rate decreased by 2.0 – 3.1 percent in CP3 and CP5 relative to No Action during 10 percent of the years simulated (8 out of 80 years). However, the habitat mortality rate increased by 2.1 – 8.5 percent during 15 percent of the years simulated (12 out of 80 years). Similar to No Action, the survival rate of late fall-run fry ranged from 59.7– 80.4 percent throughout the simulation period. The survival rate of late fall-run fry increased by 2.1 – 2.3 percent in CP3 and CP5 relative to No Action during only 5 percent of the years simulated (4 out of 80 years); however, the survival rate decreased by 2.0 – 7.3 percent during 14 percent of the years simulated (11 out of 80 years).

In summary, using the 1999 - 2006 population average, CP3 and CP5 resulted in little change in the average and median survival rates of late fall-run Chinook salmon fry relative to No Action (average survival rate: CP3 and CP5 = 64.9 percent, No Action = 65.2 percent; median survival rate CP3 and CP5 = 63.5 percent, No Action = 63.8 percent). CP3 and CP5 resulted in an increase in the average number of late fall-run fry by 66,961 relative to No Action, and an increase in the median number of late fall-run fry survivors by 60,310.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for late fall-run Chinook salmon fry in CP3 and CP5 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 4.5 – 43.5 percent with an average rate of 28.3 percent (median of 33.1 percent). The habitat mortality rate decreased by 2.3 – 6.4 percent in CP3 and CP5 relative to No Action during 5 percent of the years simulated (4 out of 80 years). However, the habitat mortality rate increased by 2.1 – 16.4 percent during 19 percent of the years simulated (15 out of 80 years). Similar to No Action, the survival rate of late fall-run fry ranged from 46.1 – 80.5 percent throughout the simulation period. The survival rate of late fall-run fry increased by 2.1 – 5.8 percent in CP3 and CP5 relative to No Action during only 4 percent of the years simulated (3 out of 80 years); however, the survival rate decreased by 2.1 – 14.5 percent during 16 percent of the years simulated (13 out of 80 years).

In summary, using the AFRP population goals, CP3 and CP5 resulted in little change in the average and median survival rates of late fall-run Chinook salmon fry relative to No Action (average survival rate: CP3 and CP5= 58.4 percent, No Action = 59.1 percent; median survival rate CP3 and CP5 = 54.1 percent, No Action = 54.3 percent). CP3 and CP5 resulted in an increase in the average annual number of late fall-run fry by 74,695 relative to No Action and an increase in the median number of late fall-run fry survivors by 24,201.

CP4

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for late fall-run Chinook salmon fry in CP4 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 4.2 – 27.4 percent with an average rate of 20.4 percent (median of 21.6 percent). The habitat mortality rate decreased by 2.0 – 4.3 percent in CP4 relative to No Action during 14 percent of the years simulated (11 out of 80 years). However, the habitat mortality rate increased by 2.1 – 5.2 percent during 10 percent of the years simulated (8 out of 80 years). Similar to No Action, the survival rate of late fall-run fry ranged from 59.6– 80.6 percent throughout the simulation period. The survival rate of late fall-run fry increased by 2.0 – 3.0 percent in CP4 relative to No Action during only 6 percent of the years simulated (5 out of 80 years); however, the survival rate decreased by 2.0 – 4.7 percent during 6 percent of the years simulated (5 out of 80 years).

In summary, using the 1999 - 2006 population average, CP4 resulted in little change in the average and median survival rates of late fall-run Chinook salmon fry relative to No Action (average survival rate: CP4 = 65.3 percent, No Action = 65.2 percent; median survival rate CP4 = 64.0 percent, No Action = 63.8 percent). CP4 resulted in an increase in the average number of late fall-run fry by 199,350 relative to No Action and an increase in the median number of late fall-run fry survivors by 168,589.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to habitat constraints (*i.e.*, forced migration of fry due to flows or fish density) was the only significant source of mortality for late fall-run Chinook salmon fry in CP4 throughout the simulation period. Similar to No Action, the mortality rate due to habitat constraints ranged from 3.7 – 43.2 percent with an average rate of 28.0 percent (median of 32.9 percent). The habitat mortality rate decreased by 2.5 – 9.6 percent in CP4 relative to No Action during 4 percent of the years simulated (3 out of 80 years). However, the habitat mortality rate increased by 2.0 – 9.9 percent in CP4 relative to No Action during 14 percent of the years simulated (11 out of 80 years). Similar to No Action, the survival rate of late fall-run fry ranged from 46.1 – 81.0 percent throughout the simulation period. The survival rate of late fall-run fry increased by 2.0 – 8.2 percent in CP4 relative to No Action during only 3 percent of the years simulated (2 out of 80 years); however, the survival rate decreased by 2.1 – 8.8 percent during 10 percent of the years simulated (8 out of 80 years).

In summary, using the AFRP population goals, CP4 resulted in little change in the average and median survival rates of late fall-run Chinook salmon fry relative to No Action (average survival rate: CP4= 58.7 percent, No Action = 59.1 percent; median survival rate CP4 = 54.2 percent, No Action = 54.3 percent). CP4 resulted in an increase in the average annual number of late fall-run fry by 251,456 relative to No Action and an increase in the median number of late fall-run fry survivors by 118,505.

Pre-Smolt Mortality

The survival rates and sources of mortality of late fall-run Chinook salmon pre-smolts using the 1999 – 2006 population average are illustrated in Figures B-57A-C and B-58A-E. The survival rates and sources of mortality of late fall-run Chinook salmon pre-smolts using the AFRP population goals are illustrated in Figures B-59A-C and B-60A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon pre-smolts in the No Action Alternative during 91 percent of the years simulated (73 out of 80 years). The mortality rate for entrainment in unscreened water diversions ranged from 1.0 – 4.4 percent with an average rate of 3.0 percent (median of 3.0 percent). The mortality rate due to habitat constraints ranged from 0.0 – 1.7 percent with an average rate of 0.2 percent (median of 0.1 percent). However, Salmod likely underestimates the mortality of late fall-run pre-smolts caused by habitat constraints due to the model's inability to simulate resource competition among the four runs of Chinook salmon and steelhead. The thermal mortality rate for late fall-run pre-smolts exceeded 2 percent only during 9 percent of the years simulated (7 out of 80 years) when the thermal mortality rate ranged from 3.1 – 14.8 percent. The survival rate of late fall-run pre-smolts ranged from 63.4 – 77.1 percent throughout the simulation period with an average rate of 75.2 percent (median of 75.7 percent). The number of late fall-run pre-smolt survivors ranged from 6,212,513– 8,882,032 during 96 percent of the years simulated (77 out of 80 years). The number of late fall-run pre-smolts survivors dropped to 3,011,349 – 4,675,415 during the remaining 4 percent of the years simulated primarily due to the mortality of late fall-run eggs from superimposition and the flushing or dewatering of redds.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon pre-smolts in the No Action Alternative during 91 percent of the years simulated (73 out of 80 years). The mortality rate for entrainment in unscreened water diversions ranged from 1.0 – 4.3 percent with an average rate of 2.9 percent (median of 3.0 percent). The mortality rate due to habitat constraints ranged from 0.0 – 1.7 percent with an average rate of 0.4 percent (median of 0.2 percent). However, Salmod likely underestimates the mortality of late fall-run pre-smolts caused by habitat constraints due to the model's inability to simulate resource competition among the four runs of Chinook salmon and steelhead. The thermal mortality rate for late fall-run pre-smolts exceeded 2 percent only during 9 percent of the years simulated (7 out of 80 years) when the thermal mortality rate ranged from 3.3 – 14.6 percent. The survival rate of late fall-run pre-smolts ranged from 63.6 – 77.3 percent throughout the simulation period with an average rate of 75.4 percent (median of 76.0 percent). The number of late fall-run pre-smolt survivors ranged from 9,297,227 – 15,259,854 during 96 percent of the years simulated (77 out of 80 years). The number of late fall-run pre-smolt survivors dropped to 4,095,225 – 6,534,374 during the remaining 4 percent of the years simulated primarily due to the mortality of late fall-run eggs from superimposition and the flushing or dewatering of redds.

CP1

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon pre-smolts in CP1 during 91 percent of the years simulated (73 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 1.0 - 4.5 percent with an average rate of 2.9 percent (median of 2.9 percent). The mortality rate due to habitat constraints ranged from 0.0 – 0.9 percent with an average rate of 0.2 percent (median of 0.1 percent). Like in No Action, significant thermal mortality of late fall-run pre-smolts (greater than 2 percent) occurred during 9 percent of the years simulated (7 out of 80 years) when thermal mortality rates were 2.3 – 14.3 percent. CP1 resulted in a decrease in thermal mortality by 1.8 – 4.4 percent relative to No Action during five years but an increase in thermal mortality by 2.4 percent during one year. Similar to No Action, the survival rate of late fall-run pre-smolts ranged from 63.7 – 77.1 percent throughout the simulation period. The survival rate of late fall-run pre-smolts increased by 3.6 – 4.6 percent in CP1 relative to No Action during only 4 percent of the years simulated (3 out of 80 years); however, the survival rate decreased by 3.0 percent during 1 percent of the years simulated (1 out of 80 years).

In summary, using the 1999 - 2006 population average, CP1 resulted in little change in the average and median survival rates of late fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP1 = 75.3 percent, No Action = 75.2 percent; median survival rate CP1 = 75.6 percent, No Action = 75.7 percent). CP1 resulted in an increase in the average number of late fall-run pre-smolt survivors by 42,320 relative to No Action and an increase in the median number of late fall-run pre-smolt survivors by 22,895.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon pre-smolts in CP1 during 91 percent of the years simulated (73 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 1.0 - 4.3 percent with an average rate of 2.9 percent (median of 2.9 percent). The mortality rate due to habitat constraints ranged from 0.0 – 3.0 percent with an average rate of 0.4 percent (median of 0.2 percent). Like in No Action, significant thermal mortality of late fall-run pre-smolts (greater than 2 percent) occurred during 9 percent of the years simulated (7 out of 80 years) when thermal mortality rates were 2.6 – 14.3 percent. CP1 resulted in a decrease in thermal mortality by 1.8 – 4.5 percent relative to No Action during five years but an increase in thermal mortality by 2.3 percent during one year. Similar to No Action, the survival rate of late fall-run pre-smolts ranged from 62.6 – 77.0 percent throughout the simulation period. The survival rate of late fall-run pre-smolts increased by 2.0 – 5.2 percent in CP1 relative to No Action during 6 percent of the years simulated (5 out of 80 years); however, the survival rate decreased by 2.8 percent during 1 percent of the years simulated (1 out of 80 years).

In summary, using the AFRP population goals, CP1 resulted in little change in the average and median survival rates of late fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP1 = 75.4 percent, No Action = 75.4 percent; median survival rate CP1 = 75.8 percent, No Action = 76.0 percent). CP1 resulted in an increase in the average number of late fall-run pre-smolt survivors by 44,151 relative to No Action and an increase in the median number of late fall-run pre-smolt survivors by 13,760.

CP2

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon pre-smolts in CP2 during 91 percent of the years simulated (73 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 1.0 - 4.5 percent with an average rate of 3.0 percent (median of 2.9 percent). The mortality rate due to habitat constraints ranged from 0.0 – 1.4 percent with an average rate of 0.2 percent (median of 0.1 percent). Like in No Action, significant thermal mortality of late fall-run pre-smolts (greater than 2 percent) occurred during 9 percent of the years simulated (7 out of 80 years) when thermal mortality rates were 2.2 – 14.9 percent. CP2 resulted in a decrease in thermal mortality by 2.2 – 4.5 percent relative to No Action during four years but an increase in thermal mortality by 3.0 percent during one year. Similar to No Action, the survival rate of late fall-run pre-smolts ranged from 63.3 – 77.0 percent throughout the simulation period. The survival rate of late fall-run pre-smolts increased by 3.2 – 3.9 percent in CP2 relative to No Action during only 4 percent of the years simulated (3 out of 80 years); however, the survival rate decreased by 3.4 percent during 1 percent of the years simulated (1 out of 80 years).

In summary, using the 1999 - 2006 population average, CP2 resulted in little change in the average and median survival rates of late fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP2 = 75.2 percent, No Action = 75.2 percent; median survival rate CP2 = 75.5 percent, No Action = 75.7 percent). CP2 resulted in an increase in the average number of late fall-run pre-smolt survivors by 28,361 relative to No Action and an increase in the median number of late fall-run pre-smolt survivors by 4,276.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon pre-smolts in CP2 during 91 percent of the years simulated (73 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 1.0 - 4.4 percent with an average rate of 2.9 percent (median of 3.0 percent). The mortality rate due to habitat constraints ranged from 0.0 – 3.5 percent with an average rate of 0.4 percent (median of 0.2 percent). Like in No Action, significant thermal mortality of late fall-run pre-smolts (greater than 2 percent) occurred during 9 percent of the years simulated (7 out of 80 years) when thermal mortality rates were 2.5 – 14.7 percent. CP2 resulted in a decrease in thermal mortality by 2.1 – 4.6 percent relative to No Action during four years but an increase in thermal mortality by 2.7 percent during one year. Similar to No Action, the survival rate of late fall-run pre-smolts ranged from 62.8 – 76.9 percent throughout the simulation period. The survival rate of late fall-run pre-smolts increased by 2.1 – 4.5 percent in CP2 relative to No Action during 5 percent of the years simulated (4 out of 80 years); however, the survival rate decreased by 2.6 percent during 1 percent of the years simulated (1 out of 80 years).

In summary, using the AFRP population goals, CP2 resulted in little change in the average and median survival rates of late fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP2 = 75.3 percent, No Action = 75.4 percent; median survival rate CP2 = 75.7 percent, No Action = 76.0 percent). CP2 resulted in an increase in the average number of late fall-run pre-smolt survivors by 20,474 relative to No Action but a *decrease* in the median number of late fall-run pre-smolt survivors by 32,947.

CP3 and CP5

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon pre-smolts in CP3 and CP5 during 91 percent of the years simulated (73 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 1.0 - 4.5 percent with an average rate of 3.0 percent (median of 3.0 percent). The mortality rate due to habitat constraints ranged from 0.0 – 1.6 percent with an average rate of 0.2 percent (median of 0.1 percent). Significant thermal mortality of late fall-run pre-smolts (greater than 2 percent) occurred during 8 percent of the years simulated (6 out of 80 years) when thermal mortality rates were 2.2 – 12.9 percent. CP3 and CP5 resulted in a decrease in thermal mortality by 2.9 – 6.2 percent relative to No Action during four years. Similar to No Action, the survival rate of late fall-run pre-smolts ranged from 65.0 – 76.9 percent throughout the simulation period. The survival rate of late fall-run pre-smolts increased by 2.6 – 5.9 percent in CP3 and CP5 relative to No Action during only 5 percent of the years simulated (4 out of 80 years).

In summary, using the 1999 - 2006 population average, CP3 and CP5 resulted in little change in the average and median survival rates of late fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP3 and CP5 = 75.1 percent, No Action = 75.2 percent; median survival rate CP3 and CP5 = 75.3 percent, No Action = 75.7 percent). CP3 and CP5 resulted in an increase in the average number of late fall-run pre-smolt survivors by 41,916 relative to No Action and an increase in the median number of late fall-run pre-smolt survivors by 9,100.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon pre-smolts in CP3 and CP5 during 91 percent of the years simulated (73 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 1.1 - 4.4 percent with an average rate of 3.0 percent (median of 3.0 percent). The mortality rate due to habitat constraints ranged from 0.0 – 3.7 percent with an average rate of 0.4 percent (median of 0.2 percent). Like in No Action, significant thermal mortality of late fall-run pre-smolts (greater than 2 percent) occurred during 9 percent of the years simulated (7 out of 80 years) when thermal mortality rates were 2.1 – 13.0 percent. CP3 and CP5 resulted in a decrease in thermal mortality by 2.8 – 6.1 percent relative to No Action during four years. Similar to No Action, the survival rate of late fall-run pre-smolts ranged from 63.8 – 76.9 percent throughout the simulation period. The survival rate of late fall-run pre-smolts increased by 2.7 – 5.2 percent in CP3 and CP5 relative to No Action during 5 percent of the years simulated (4 out of 80 years).

In summary, using the AFRP population goals, CP3 and CP5 resulted in little change in the average and median survival rates of late fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP3 and CP5 = 75.3 percent, No Action = 75.4 percent; median survival rate CP3 and CP5 = 75.7 percent, No Action = 76.0 percent). CP3 and CP5 resulted in an increase in the average number of late fall-run pre-smolts by 48,387 relative to No Action but a *decrease* in the median number of late fall-run pre-smolt survivors by 18,063.

CP4

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon pre-smolts in CP4 during 98 percent of the years simulated (78 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 1.0 - 4.5 percent with an average rate of 2.9 percent (median of 3.0 percent). The mortality rate due to habitat constraints ranged from 0.0 – 1.1 percent with an average rate of 0.2 percent (median of 0.1 percent). Significant thermal mortality of late fall-run pre-smolts (greater than 2 percent) occurred only during 1 percent of the years simulated (1 out of 80 years) when thermal mortality rate was 2.1 percent (compared to No Action in which 9 percent of the years simulated had thermal mortality rates exceeding 2 percent). CP4 resulted in a decrease in thermal mortality rate by 3.1 – 13.5 percent relative to No Action during seven years.

In summary, using the 1999 - 2006 population average, the survival rate of late fall-run pre-smolts in CP4 ranged from 74.4 – 77.1 percent throughout the simulation period. The survival rate of late fall-run pre-smolts increased by 2.2 – 13.4 percent in CP4 relative to No Action during 9 percent of the years simulated (7 out of 80 years). However, CP4 resulted in little change in the average and median survival rates of late fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP4 = 75.3 percent, No Action = 75.2 percent; median survival rate CP4 = 75.1 percent, No Action = 75.7 percent). CP4 resulted in an increase in the average number of late fall-run pre-smolt survivors by 162,758 relative to No Action and an increase in the median number of late fall-run pre-smolt survivors by 86,150.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon pre-smolts in CP4 during 95 percent of the years simulated (76 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 1.1 - 4.4 percent with an average rate of 2.9 percent (median of 3.0 percent). The mortality rate due to habitat constraints ranged from 0.0 – 3.5 percent with an average rate of 0.5 percent (median of 0.3 percent). Significant thermal mortality of late fall-run pre-smolts (greater than 2 percent) occurred only during 1 percent of the years simulated (1 out of 80 years) when thermal mortality rate was 2.3 percent (compared to No Action in which 9 percent of the years simulated had thermal mortality rates exceeding 2 percent). CP4 resulted in a decrease in thermal mortality rate by 3.3 – 13.2 percent relative to No Action during seven years.

In summary, using the AFRP population goals, the survival rate of late fall-run pre-smolts in CP4 ranged from 72.8 – 77.0 percent throughout the simulation period. The survival rate of late fall-run pre-smolts increased by 2.4 – 12.7percent in CP4 relative to No Action during 9 percent of the years simulated (7 out of 80 years). However, CP4 resulted in little change in the average and median survival rates of late fall-run Chinook salmon pre-smolts relative to No Action (average survival rate: CP4 = 75.4 percent, No Action = 75.2 percent; median survival rate CP4 = 75.4 percent, No Action = 75.7 percent). CP4 resulted in an increase in the average number of late fall-run pre-smolt survivors by 214,137 relative to No Action and an increase in the median number of late fall-run pre-smolt survivors by 1,616.

Immature Smolt Mortality

The survival rates and sources of mortality of late fall-run Chinook salmon immature smolts using the 1999 – 2006 population average are illustrated in Figures B-61A-C and B-62A-E. The survival rates and sources of mortality of late fall-run Chinook salmon immature smolts using the AFRP population goals are illustrated in Figures B-63A-C and B-64A-E.

No Action

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon immature smolts in the No Action Alternative during 90 percent of the years simulated (72 out of 80 years). The mortality rate for entrainment of immature smolts in unscreened water diversions ranged from 0.6 – 2.7 percent with an average rate of 1.6 percent (median of 1.6 percent). The thermal mortality rate for late fall-run immature smolts exceeded 2 percent only during 9 percent of the years simulated (7 out of 80 years) when the thermal mortality rate ranged from 2.1 – 7.3 percent. The mortality rate due to habitat constraints was insignificant throughout the simulation period. However, Salmod likely underestimates the mortality of late fall-run immature smolts caused by habitat constraints due to the model’s inability to simulate resource competition among the four runs of Chinook salmon and steelhead. The survival rate of late fall-run immature smolts ranged from 82.7 – 98.6 percent throughout the simulation period with an average rate of 94.9 percent (median of 95.5 percent). The number of late fall-run immature smolt survivors ranged from 6,030,952 – 8,251,566 during 96 percent of the years simulated (77 out of 80 years). The number of late fall-run immature smolts survivors dropped to 2,878,560 – 4,527,873 during the remaining 4 percent of the years simulated primarily due to the mortality of late fall-run eggs from superimposition and the flushing or dewatering of redds.

Using the AFRP population goals, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon immature smolts in the No Action Alternative during 90 percent of the years simulated (72 out of 80 years). The mortality rate for entrainment of immature smolts in unscreened water diversions ranged from 0.5 – 2.5 percent with an average rate of 1.5 percent (median of 1.5 percent). The thermal mortality rate for late fall-run immature smolts exceeded 2 percent only during 9 percent of the years simulated (7 out of 80 years) when the thermal mortality rate ranged from 2.1 – 7.3 percent. The mortality rate due to habitat constraints was insignificant throughout the simulation period. However, Salmod likely underestimates the mortality of late fall-run immature smolts caused by habitat constraints due to the model's inability to simulate resource competition among the four runs of Chinook salmon and steelhead. The survival rate of late fall-run immature smolts ranged from 83.5 – 98.8 percent throughout the simulation period with an average rate of 95.2 percent (median of 95.8 percent). The number of late fall-run immature smolt survivors ranged from 9,078,781 – 14,409,207 during 96 percent of the years simulated (77 out of 80 years). The number of late fall-run immature smolts survivors dropped to 3,942,196 – 6,407,331 during the remaining 4 percent of the years simulated primarily due to the mortality of late fall-run eggs from superimposition and the flushing or dewatering of redds.

CP1

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon immature smolts in CP1 during 90 percent of the years simulated (72 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 0.5 – 2.7 percent with an average rate of 1.6 percent (median of 1.6 percent). Like in No Action, significant thermal mortality of late fall-run immature smolts (greater than 2 percent) occurred during 9 percent of the years simulated (7 out of 80 years) when thermal mortality rates were 2.7 –6.4 percent. CP1 resulted in a decrease in thermal mortality by 0.9 – 1.2 percent relative to No Action during two years but an increase in thermal mortality by 0.6 – 1.5 during two years. The mortality rate due to habitat constraints was insignificant as in No Action. Similar to No Action, the survival rate of late fall-run immature smolts ranged from 83.7 – 98.8 percent throughout the simulation period. The survival rate of late fall-run immature smolts increased by 2.2 – 6.1 percent in CP1 relative to No Action during 22 percent of the years simulated (17 out of 80 years); however, the survival rate decreased by 2.0 – 2.9 percent during 13 percent of the years simulated (10 out of 80 years).

In summary, using the 1999 - 2006 population average, CP1 resulted in little change in the average and median survival rates of late fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP1 = 94.8 percent, No Action = 94.9 percent; median survival rate CP1 = 95.5 percent, No Action = 95.5 percent). CP1 resulted in an increase in the average number of late fall-run immature smolt survivors by 32,043 relative to No Action and an increase in the median number of late fall-run immature smolt survivors by 7,627.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon immature smolts in CP1 during 90 percent of the years simulated (72 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 0.5 – 2.6 percent with an average rate of 1.5 percent (median of 1.5 percent). Like in No Action, significant thermal mortality of late fall-run immature smolts (greater than 2 percent) occurred during 9 percent of the years simulated (7 out of 80 years) when thermal mortality rates were 2.8 – 6.4 percent. CP1 resulted in a decrease in thermal mortality by 0.9 percent relative to No Action during two years but an increase in thermal mortality by 0.7 – 1.3 during two years. The mortality rate due to habitat constraints was insignificant as in No Action. Similar to No Action, the survival rate of late fall-run immature smolts ranged from 84.4 – 98.8 percent throughout the simulation period. The survival rate of late fall-run immature smolts increased by 2.1 – 7.8 percent in CP1 relative to No Action during 21 percent of the years simulated (17 out of 80 years); however, the survival rate decreased by 2.0 – 3.9 percent during 14 percent of the years simulated (11 out of 80 years).

In summary, using the AFRP population goals, CP1 resulted in little change in the average and median survival rates of late fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP1 = 95.1 percent, No Action = 95.2 percent; median survival rate CP1 = 95.8 percent, No Action = 95.8 percent). CP1 resulted in an increase in the average number of late fall-run immature smolt survivors by 28,190 relative to No Action but a *decrease* in the median number of late fall-run immature smolt survivors by 29,095.

CP2

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon immature smolts in CP2 during 90 percent of the years simulated (72 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 0.5 – 2.7 percent with an average rate of 1.6 percent (median of 1.6 percent). Like in No Action, significant thermal mortality of late fall-run immature smolts (greater than 2 percent) occurred during 9 percent of the years simulated (7 out of 80 years) when thermal mortality rates were 2.2 –6.5 percent. CP2 resulted in a decrease in thermal mortality by 0.8 – 1.0 percent relative to No Action during two years but an increase in thermal mortality by 1.1 during one year. The mortality rate due to habitat constraints was insignificant as in No Action. Similar to No Action, the survival rate of late fall-run immature smolts ranged from 83.7 – 98.9 percent throughout the simulation period. The survival rate of late fall-run immature smolts increased by 2.2 – 8.0 percent in CP2 relative to No Action during 19 percent of the years simulated (15 out of 80 years); however, the survival rate decreased by 2.0 – 4.9 percent during 19 percent of the years simulated (15 out of 80 years).

In summary, using the 1999 - 2006 population average, CP2 resulted in little change in the average and median survival rates of late fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP2 = 94.9 percent, No Action = 94.9 percent; median survival rate CP2 = 95.6 percent, No Action = 95.5 percent). CP2 resulted in an increase in the average number of late fall-run immature smolt survivors by 23,866 relative to No Action and an increase in the median number of late fall-run immature smolt survivors by 1,886.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon immature smolts in CP2 during 90 percent of the years simulated (72 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 0.5 – 2.6 percent with an average rate of 1.4 percent (median of 1.4 percent). Like in No Action, significant thermal mortality of late fall-run immature smolts (greater than 2 percent) occurred during 9 percent of the years simulated (7 out of 80 years) when thermal mortality rates were 2.3 – 6.8 percent. CP2 resulted in a decrease in thermal mortality by 1.0 percent relative to No Action during one year but an increase in thermal mortality by 1.0 percent during one year. The mortality rate due to habitat constraints was insignificant as in No Action. Similar to No Action, the survival rate of late fall-run immature smolts ranged from 84.2 – 98.9 percent throughout the simulation period. The survival rate of late fall-run immature smolts increased by 2.1 – 12.3 percent in CP2 relative to No Action during 21 percent of the years simulated (17 out of 80 years); however, the survival rate decreased by 2.0 – 6.7 percent during 18 percent of the years simulated (14 out of 80 years).

In summary, using the AFRP population goals, CP2 resulted in little change in the average and median survival rates of late fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP2 = 95.2 percent, No Action = 95.2 percent; median survival rate CP2 = 95.9 percent, No Action = 95.8 percent). CP2 resulted in an increase in the average number of late fall-run immature smolt survivors by 14,317 relative to No Action but a *decrease* in the median number of late fall-run immature smolt survivors by 14,884.

CP3 and CP5

Using the 1999 – 2006 population average, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon immature smolts in CP3 and CP5 during 90 percent of the years simulated (72 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 0.5 – 2.7 percent with an average rate of 1.6 percent (median of 1.5 percent). Like in No Action, significant thermal mortality of late fall-run immature smolts (greater than 2 percent) occurred during 9 percent of the years simulated (7 out of 80 years) when thermal mortality rates were 2.2 – 6.2 percent. CP3 and CP5 resulted in a decrease in thermal mortality by 0.7 – 1.3 percent relative to No Action during five years but an increase in thermal mortality by 1.4 during one year. The mortality rate due to habitat constraints was insignificant as in No Action. Similar to No Action, the survival rate of late fall-run immature smolts ranged from 84.0 – 98.9 percent throughout the simulation period. The survival rate of late fall-run immature smolts increased by 2.1 – 11.1 percent in CP3 and CP5 relative to No Action during 25 percent of the years simulated (20 out of 80 years); however, the survival rate decreased by 2.2 – 4.8 percent during 16 percent of the years simulated (13 out of 80 years).

In summary, using the 1999 - 2006 population average, CP3 and CP5 resulted in little change in the average and median survival rates of late fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP3 and CP5 = 95.0 percent, No Action = 94.9 percent; median survival rate CP3 and CP5 = 95.6 percent, No Action = 95.5 percent). CP3 and CP5 resulted in an increase in the average number of late fall-run immature smolt survivors by 42,225 relative to No Action and an increase in the median number of late fall-run immature smolt survivors by 19,424.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon immature smolts in CP3 and CP5 during 90 percent of the years simulated (72 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 0.5 – 2.6 percent with an average rate of 1.4 percent (median of 1.4 percent). Like in No Action, significant thermal mortality of late fall-run immature smolts (greater than 2 percent) occurred during 9 percent of the years simulated (7 out of 80 years) when thermal mortality rates were 2.3 – 6.4 percent. CP3 and CP5 resulted in a decrease in thermal mortality by 0.7 – 1.3 percent relative to No Action during five years but an increase in thermal mortality by 1.1 percent during one year. The mortality rate due to habitat constraints was insignificant as in No Action. Similar to No Action, the survival rate of late fall-run immature smolts ranged from 84.3 – 99.0 percent throughout the simulation period. The survival rate of late fall-run immature smolts increased by 2.2 – 27.1 percent in CP3 and CP5 relative to No Action during 18 percent of the years simulated (14 out of 80 years); however, the survival rate decreased by 2.7 – 5.5 percent during 15 percent of the years simulated (12 out of 80 years).

In summary, using the AFRP population goals, CP3 and CP5 resulted in little change in the average and median survival rates of late fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP3 and CP5 = 95.3 percent, No Action = 95.2 percent; median survival rate CP3 and CP5 = 96.0 percent, No Action = 95.8 percent). CP3 and CP5 resulted in an increase in the average number of late fall-run immature smolt survivors by 48,723 relative to No Action but a *decrease* in the median number of late fall-run immature smolt survivors by 11,242.

CP4

Using the 1999 – 2006 population average, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon immature smolts in CP4 during 95 percent of the years simulated (76 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 0.5 – 2.8 percent with an average rate of 1.6 percent (median of 1.6 percent). Significant thermal mortality of late fall-run immature smolts (greater than 2 percent) occurred only during 1 percent of the years simulated (1 out of 80 years) when the thermal mortality rate was 3.1 percent; this is compared to No Action and the other SLWRI alternatives in which the thermal mortality rate exceeded 2 percent during 9 percent of the years simulated (7 out of 80 years). CP4 resulted in a decrease in thermal mortality by 1.3 – 5.9 percent relative to No Action during seven years. Similar to No Action, the survival rate of late fall-run immature smolts ranged from 84.6 – 98.9 percent throughout the simulation period. The survival rate of late fall-run immature smolts increased by 2.0 – 26.7 percent in CP4 relative to No Action during 35 percent of the years simulated (28 out of 80 years); however, the survival rate decreased by 2.1 – 6.0 percent during 4 percent of the years simulated (3 out of 80 years).

In summary, despite increases in survival rates exceeding 2 percent during over one-third of the years simulated, CP4 resulted in little change in the average and median survival rates of late fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP4 = 95.1 percent, No Action = 94.9 percent; median survival rate CP4 = 95.6 percent, No Action = 95.5 percent). CP4 resulted in an increase in the average number of late fall-run immature smolt survivors by 161,477 relative to No Action and an increase in the median number of late fall-run immature smolt survivors by 81,239.

Using the AFRP population goals, like in No Action, other than base mortality (normal or background levels of mortality due to predation, low dissolved oxygen levels, *etc.*), mortality due to entrainment in unscreened water diversions was the primary source of mortality for late fall-run Chinook salmon immature smolts in CP4 during 94 percent of the years simulated (75 out of 80 years). Similar to No Action, the mortality rate due to entrainment in unscreened diversions ranged from 0.4 – 2.6 percent with an average rate of 1.5 percent (median of 1.4 percent). Significant thermal mortality of late fall-run immature smolts (greater than 2 percent) occurred only during 1 percent of the years simulated (1 out of 80 years) when the thermal mortality rate was 3.5 percent; this is compared to No Action and the other SLWRI alternatives in which the thermal mortality rate exceeded 2 percent during 9 percent of the years simulated (7 out of 80 years). CP4 resulted in a decrease in thermal mortality by 1.5 – 5.9 percent relative to No Action during seven years. Similar to No Action, the survival rate of late fall-run immature smolts ranged from 85.5 – 99.0 percent throughout the simulation period. The survival rate of late fall-run immature smolts increased by 2.1 – 28.3 percent in CP4 relative to No Action during 31 percent of the years simulated (25 out of 80 years); however, the survival rate decreased by 2.2 – 4.6 percent during 9 percent of the years simulated (7 out of 80 years).

Despite increases in survival rates exceeding 2 percent during nearly one-third of the years simulated, CP4 resulted in little change in the average and median survival rates of late fall-run Chinook salmon immature smolts relative to No Action (average survival rate: CP4 = 95.4 percent, No Action = 95.2 percent; median survival rate CP4 = 95.9 percent, No Action = 95.8 percent). CP4 resulted in an increase in the average number of late fall-run immature smolt survivors by 212,805 relative to No Action and an increase in the median number of late fall-run immature smolt survivors by 14,802.

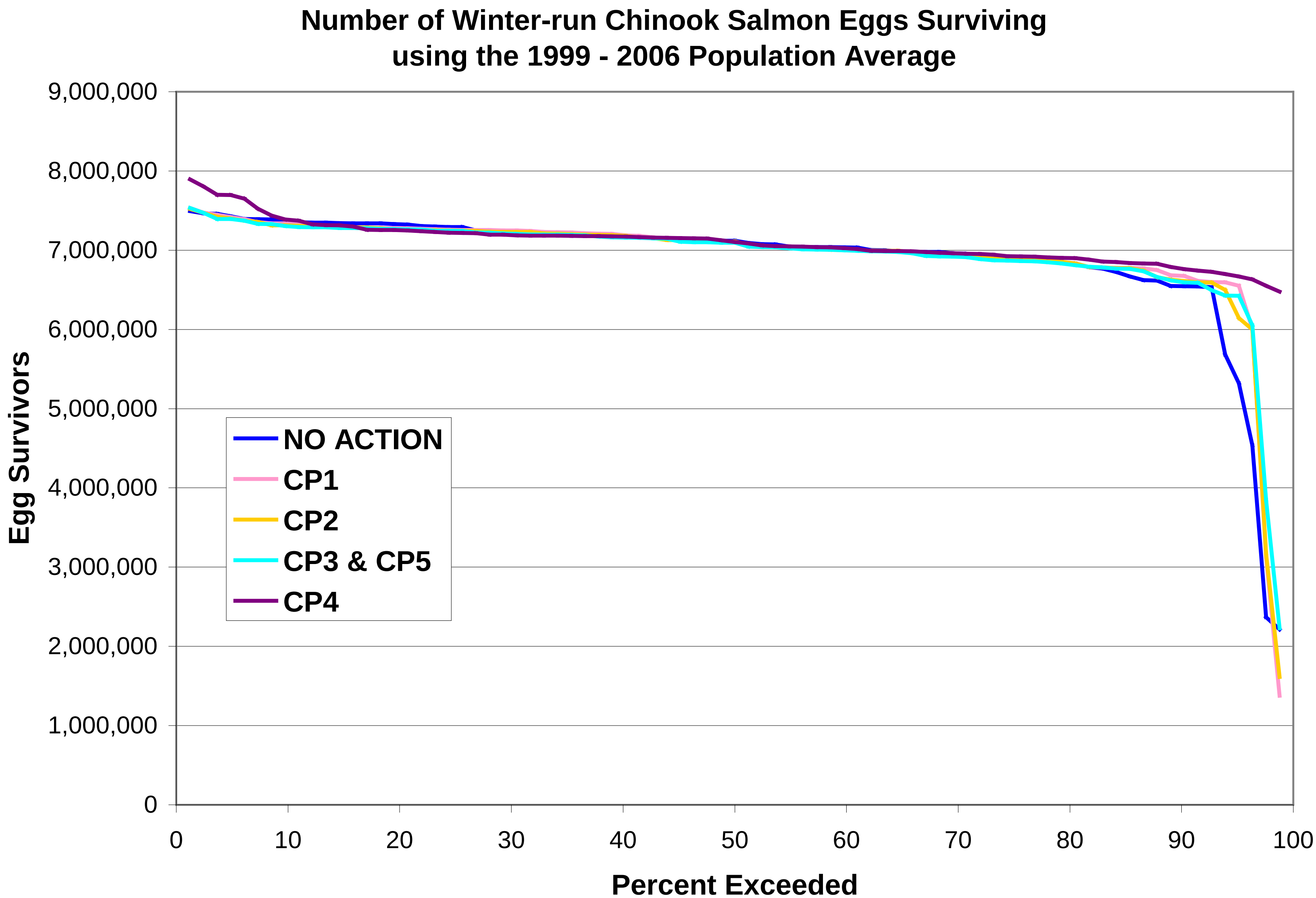

Figure B-1A. Frequency distribution of the number of winter-run Chinook salmon egg survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

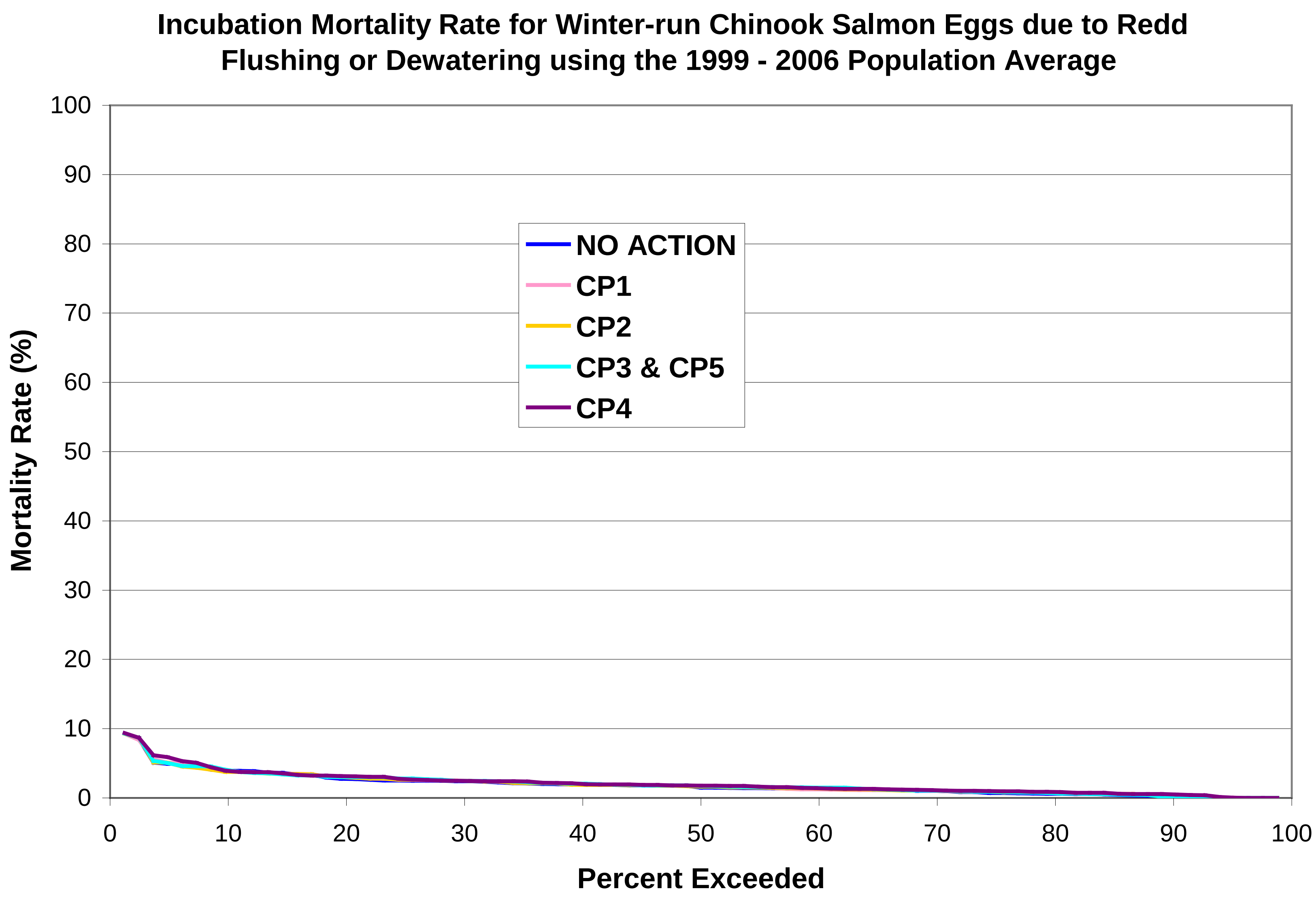

Figure B-1B. Frequency distribution of the incubation mortality rate (mortality due to the flushing or dewatering of redds) of winter-run Chinook salmon eggs during the 1921-2003 simulation period based on the 1999-2006 population average.

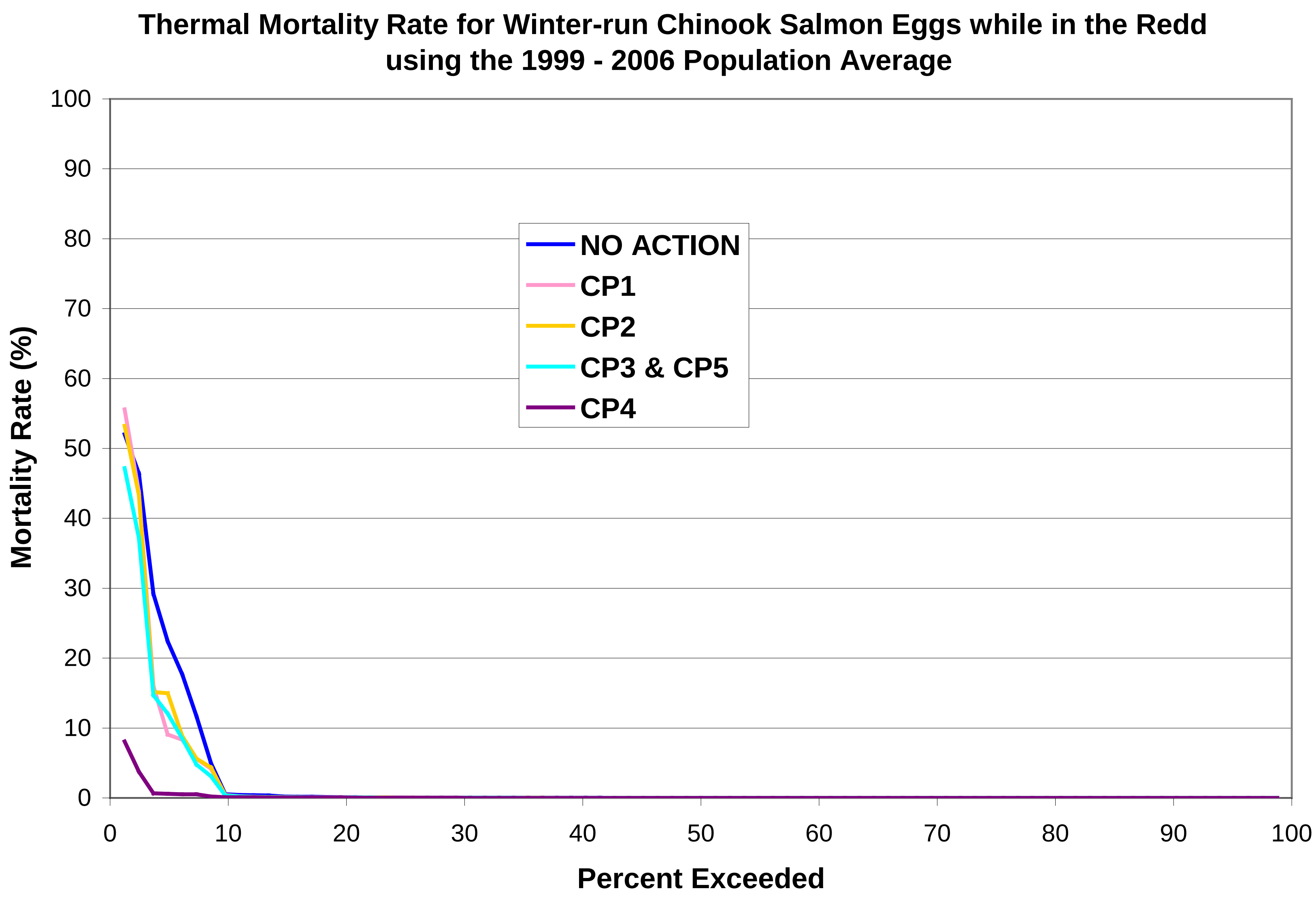

Figure B-1C. Frequency distribution of the thermal mortality rate of winter-run Chinook salmon eggs while in the redd during the 1921-2003 simulation period based on the 1999-2006 population average.

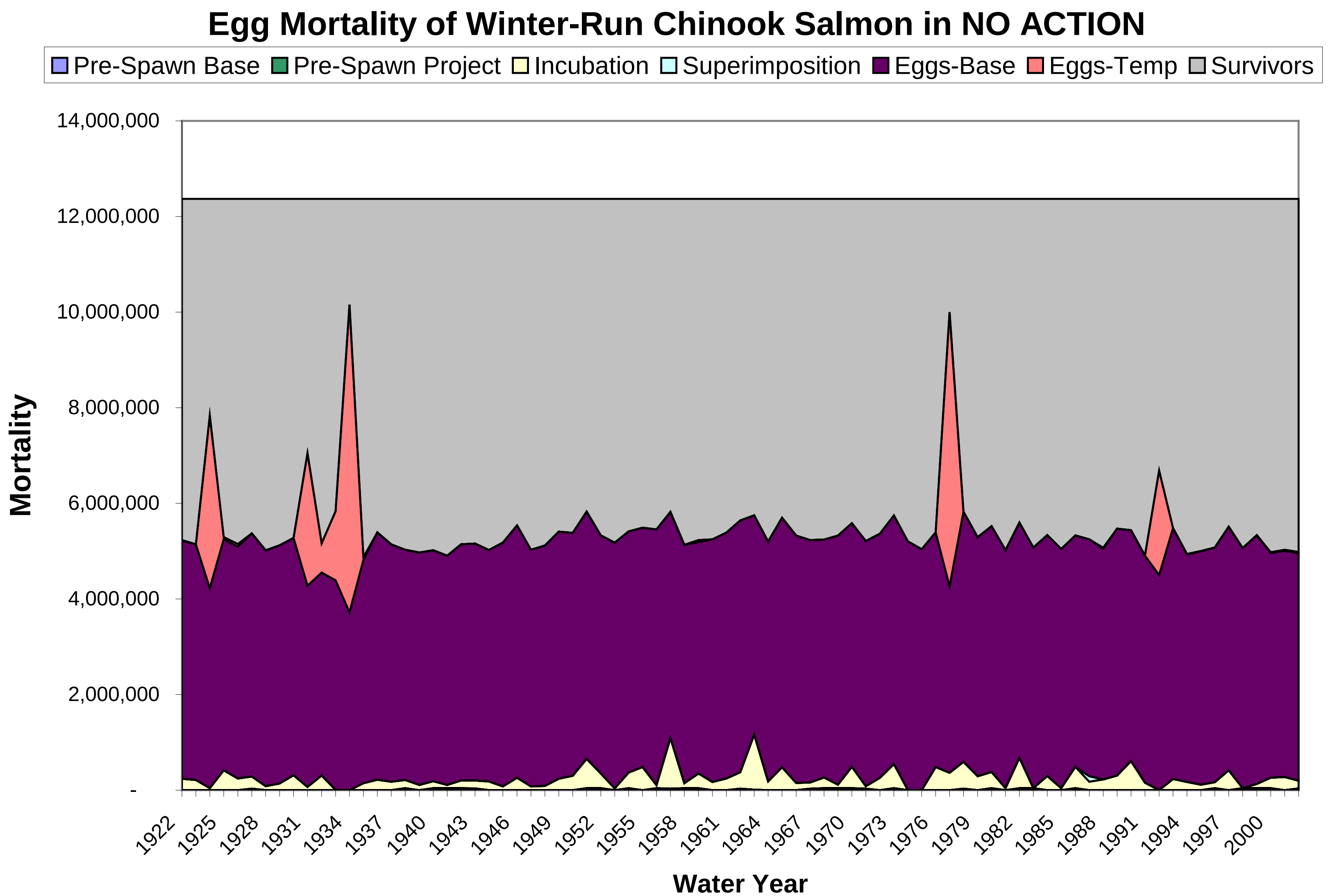

Figure B-2A. Source of mortality of winter-run Chinook salmon eggs in NO ACTION based on the 1999 – 2006 population average.

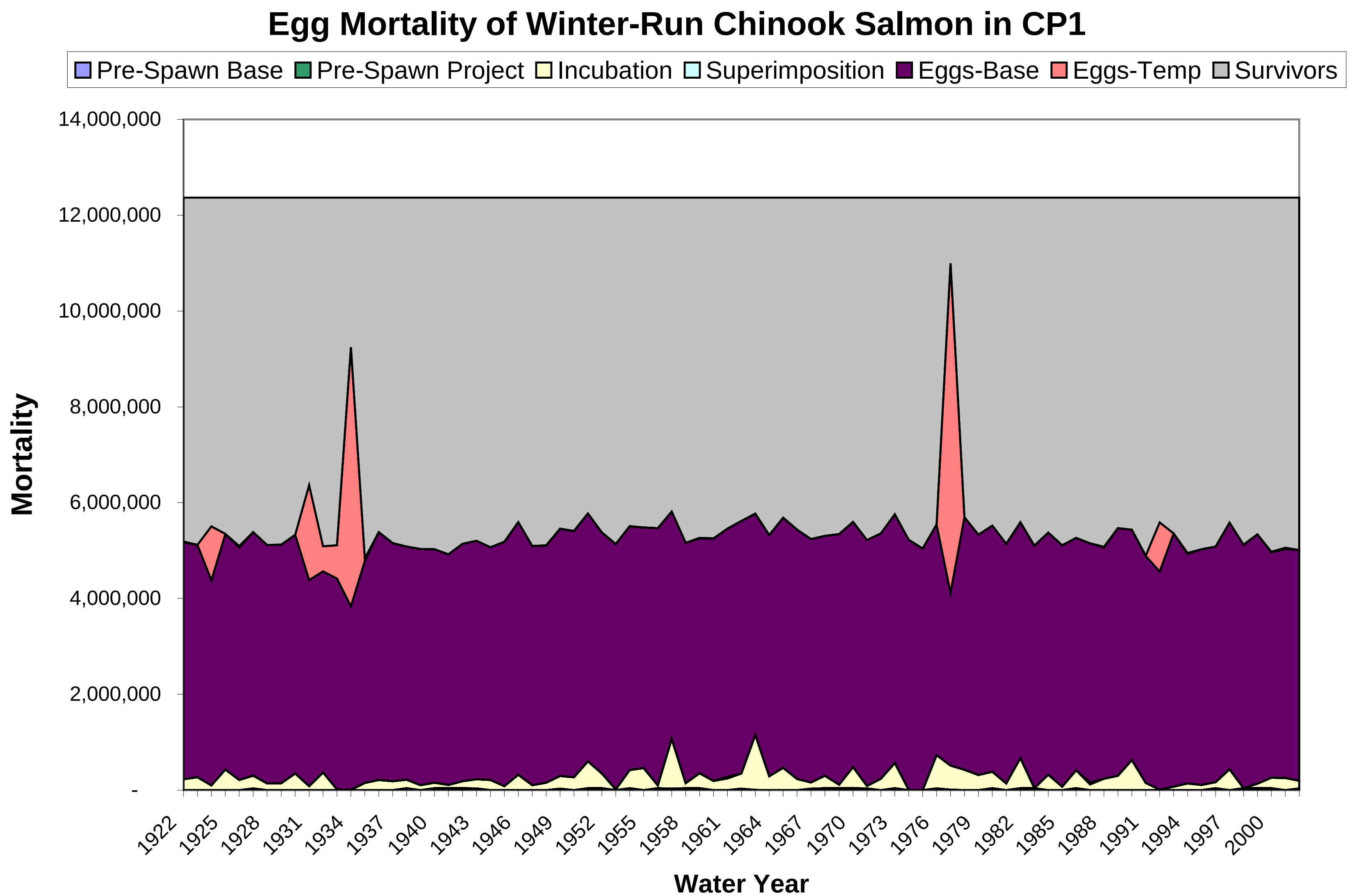

Figure B-2B. Source of mortality of winter-run Chinook salmon eggs in CP1 based on the 1999 – 2006 population average.

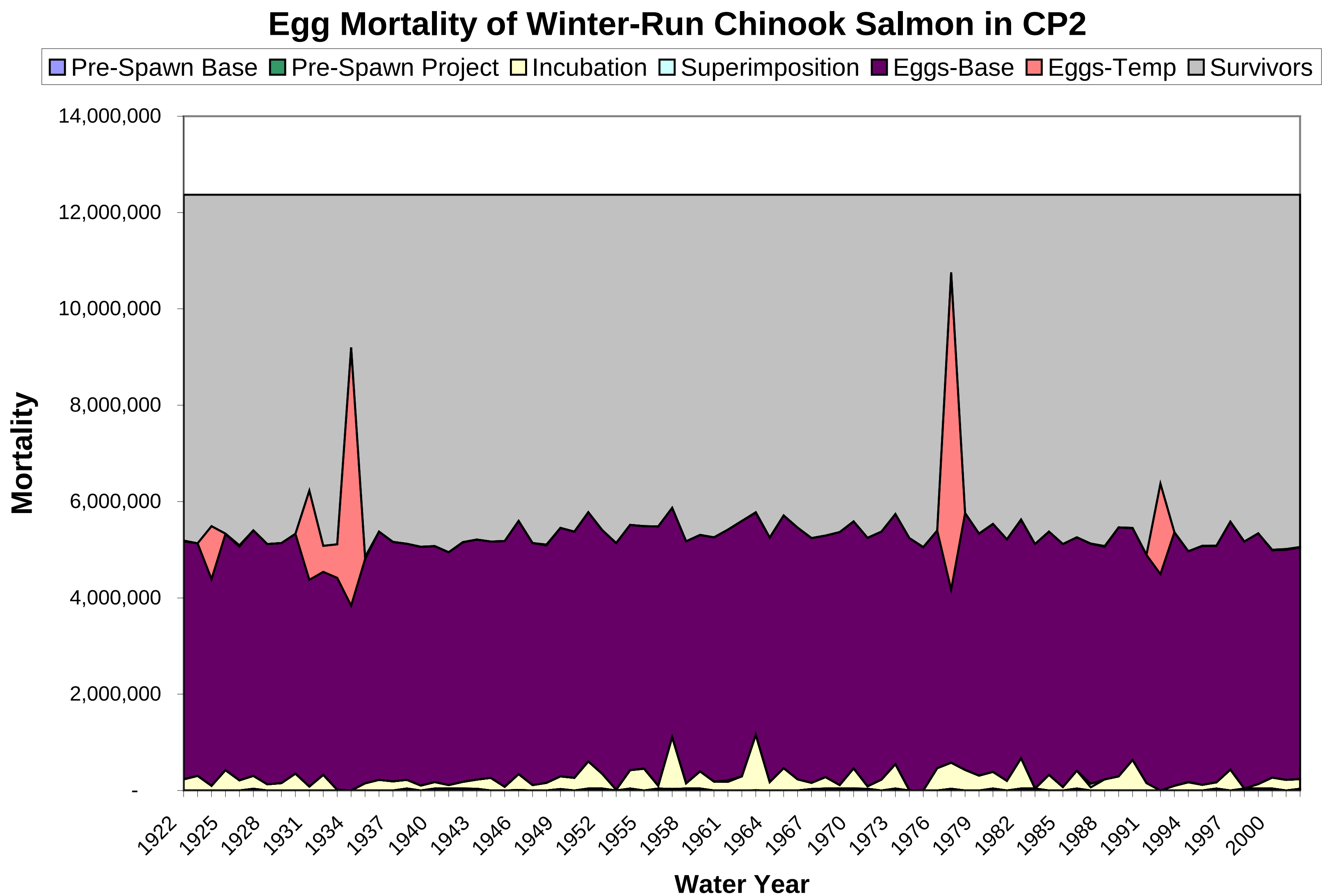

Figure B-2C. Source of mortality of winter-run Chinook salmon eggs in CP2 based on the 1999 – 2006 population average.

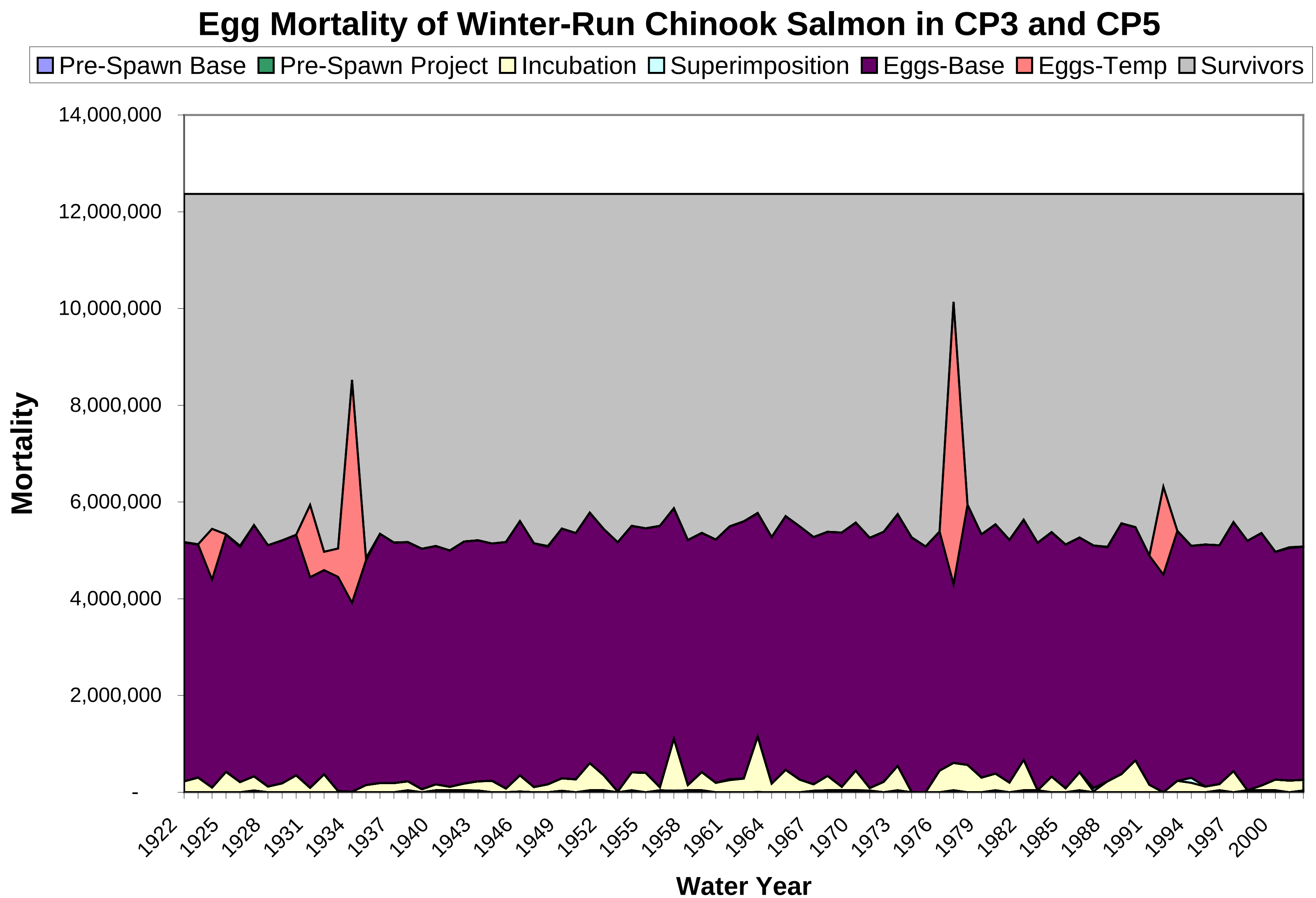

Figure B-2D. Source of mortality of winter-run Chinook salmon eggs in CP3 and CP5 based on the 1999 – 2006 population average.

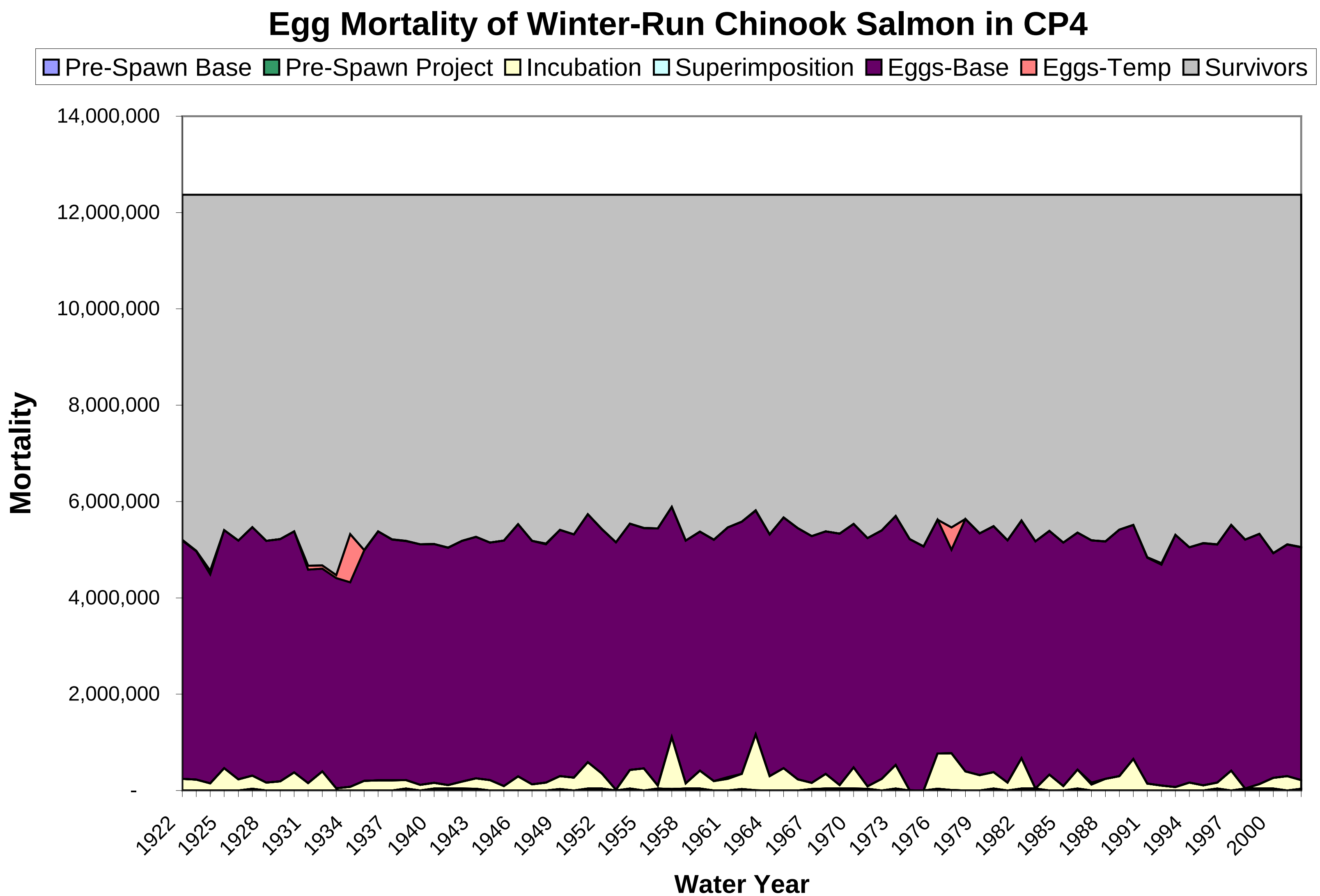

Figure B-2E. Source of mortality of winter-run Chinook salmon eggs in CP4 based on the 1999 – 2006 population average.

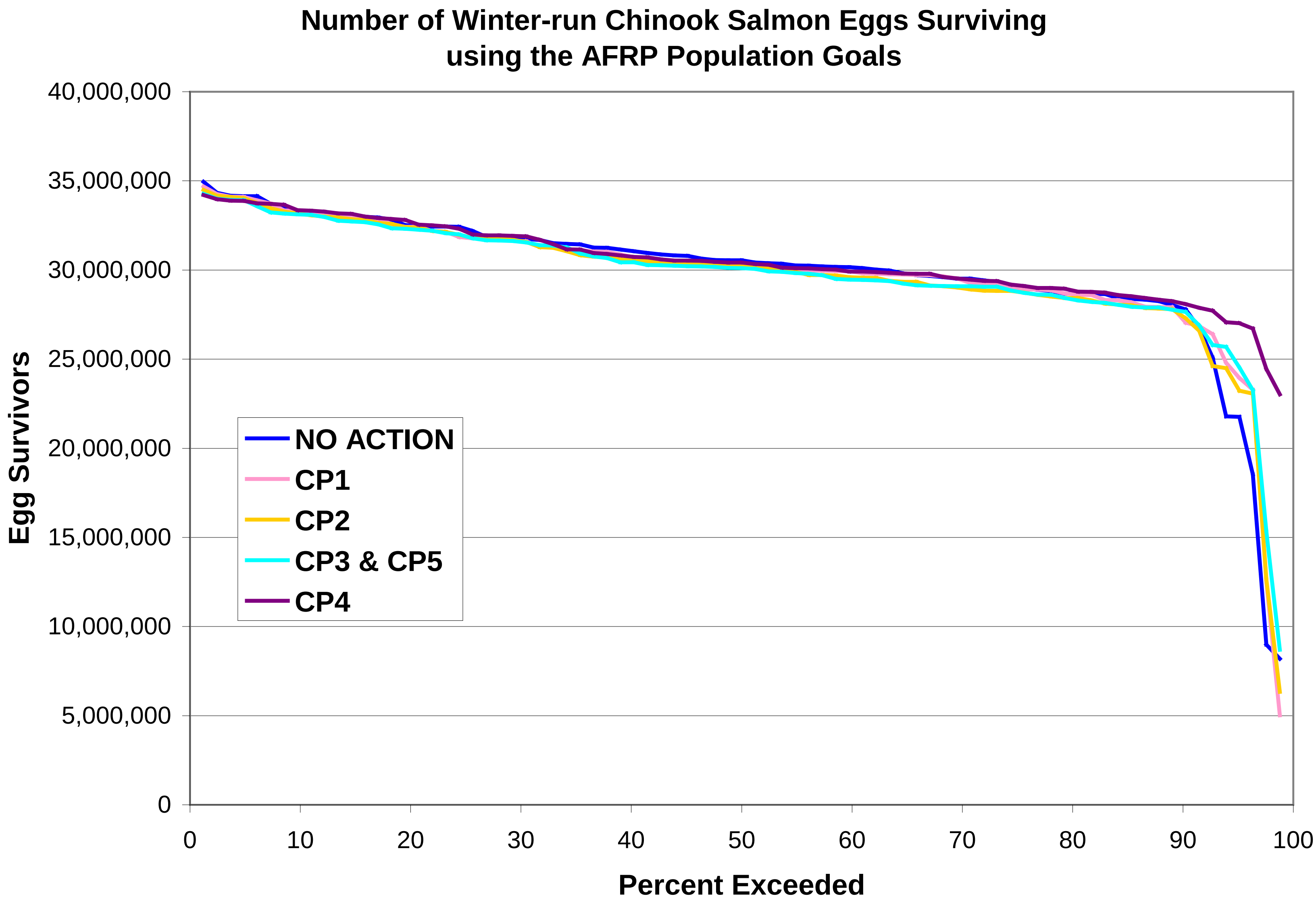

Figure B-3A. Frequency distribution of the number of winter-run Chinook salmon egg survivors during the 1921-2003 simulation period based on the AFRP population goals.

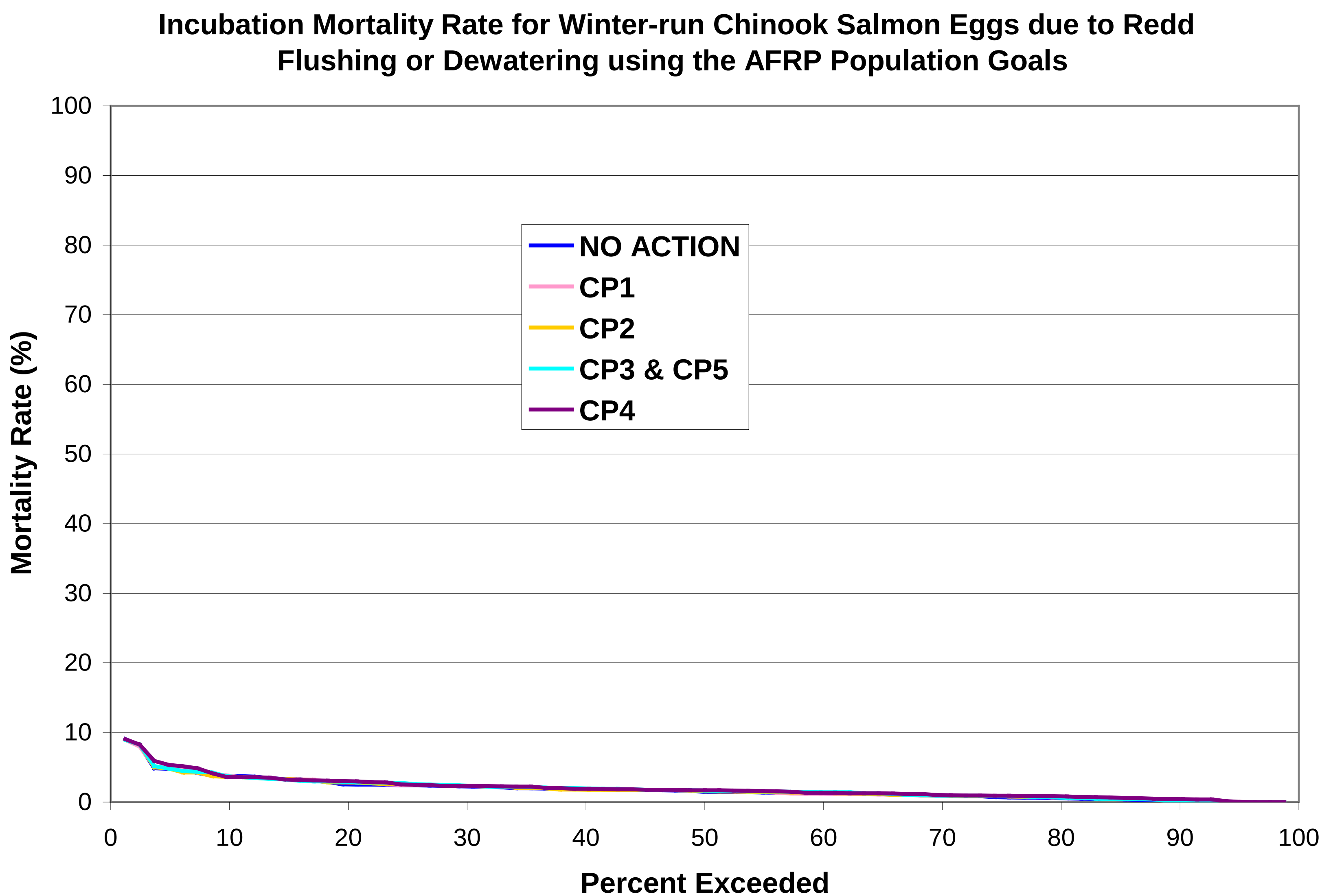

Figure B-3B. Frequency distribution of the incubation mortality rate (mortality due to the flushing or dewatering of redds) of winter-run Chinook salmon eggs during the 1921-2003 simulation period based on the AFRP population goals.

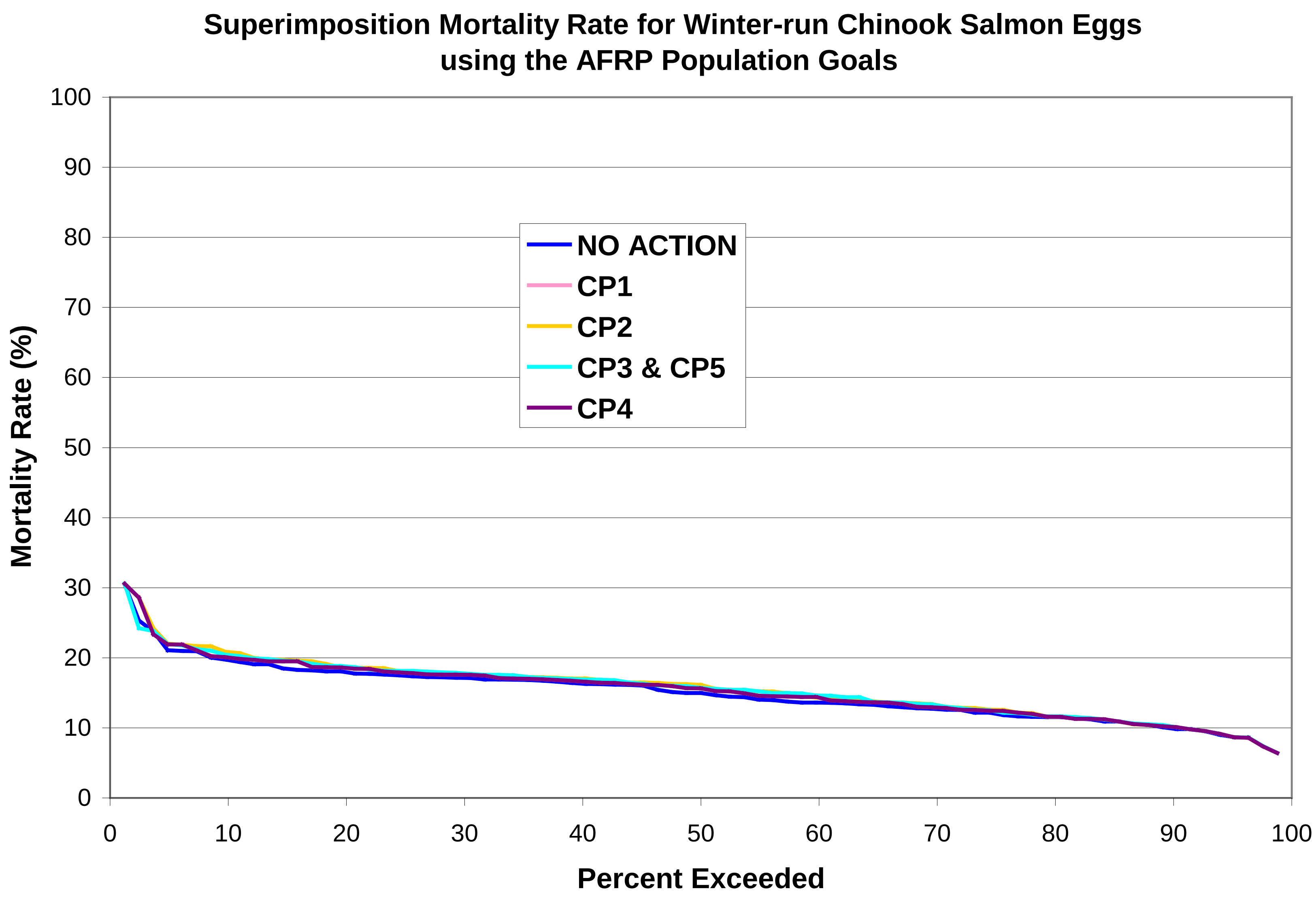

Figure B-3C. Frequency distribution of the superimposition mortality rate of winter-run Chinook salmon eggs during the 1921-2003 simulation period based on the AFRP population goals.

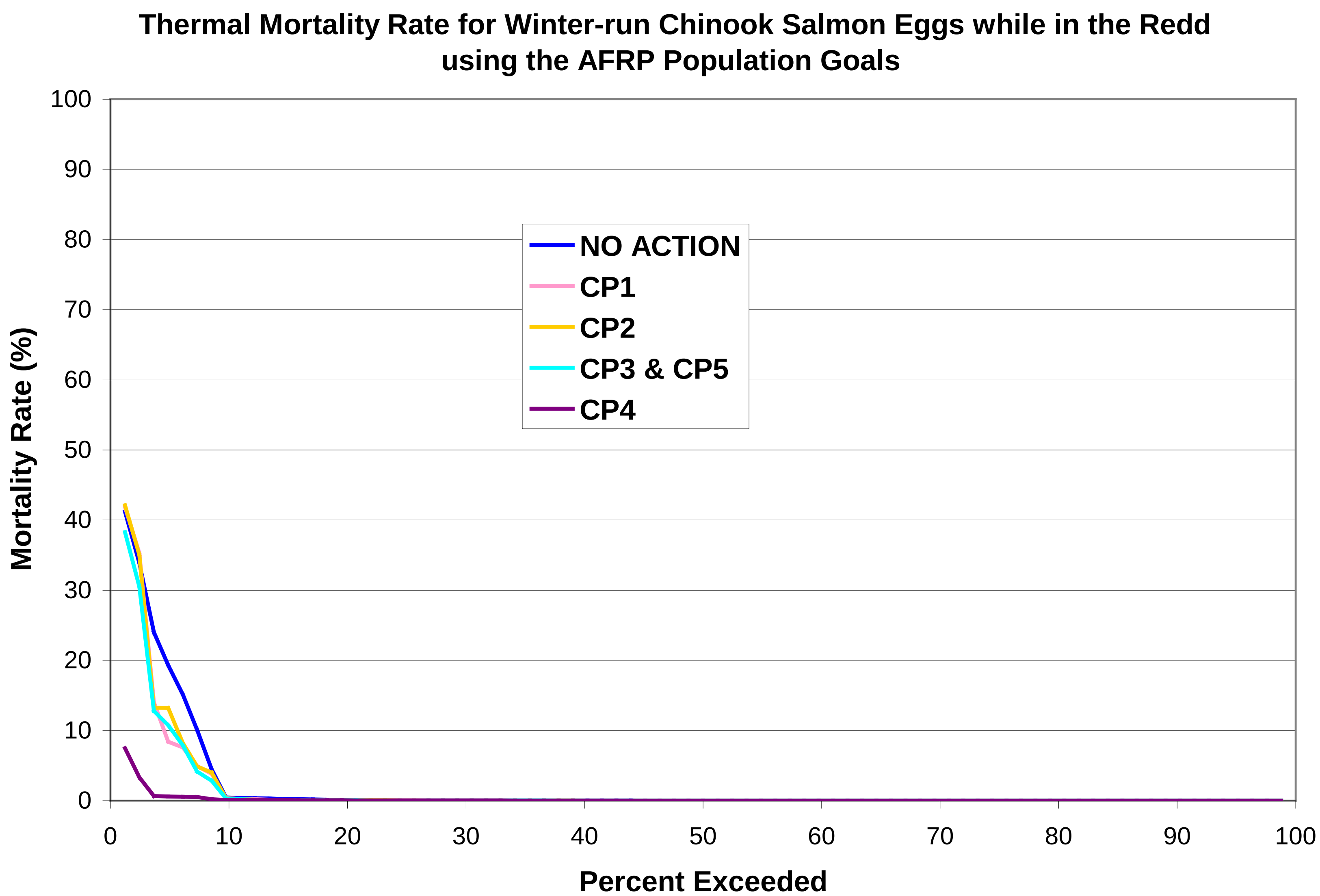

Figure B-3D. Frequency distribution of the thermal mortality rate of winter-run Chinook salmon eggs while in the redd during the 1921-2003 simulation period based on the AFRP population goals.

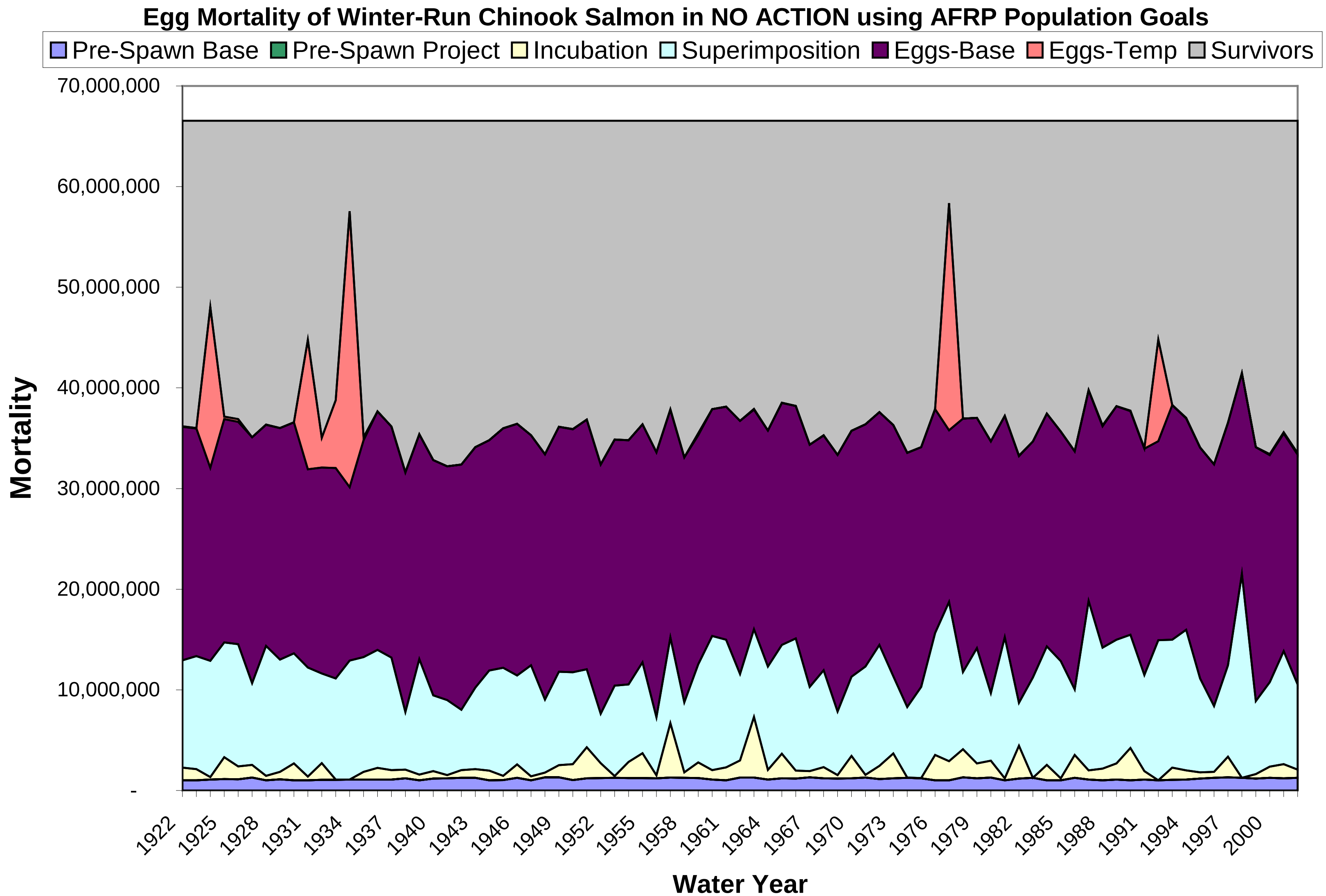

Figure B-4A. Source of mortality of winter-run Chinook salmon eggs in NO ACTION based on AFRP population goals.

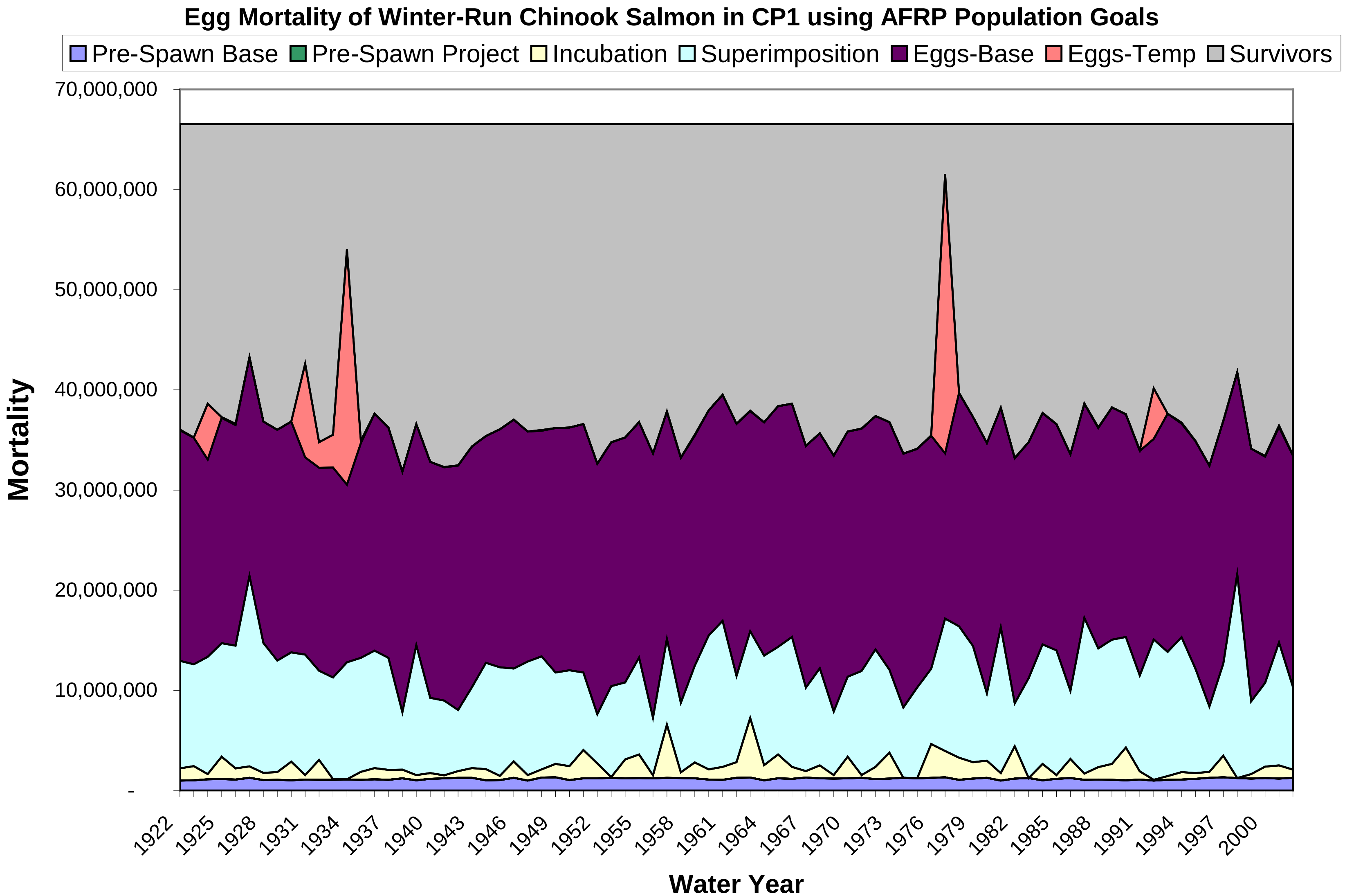

Figure B-4B. Source of mortality of winter-run Chinook salmon eggs in CP1 based on AFRP population goals.

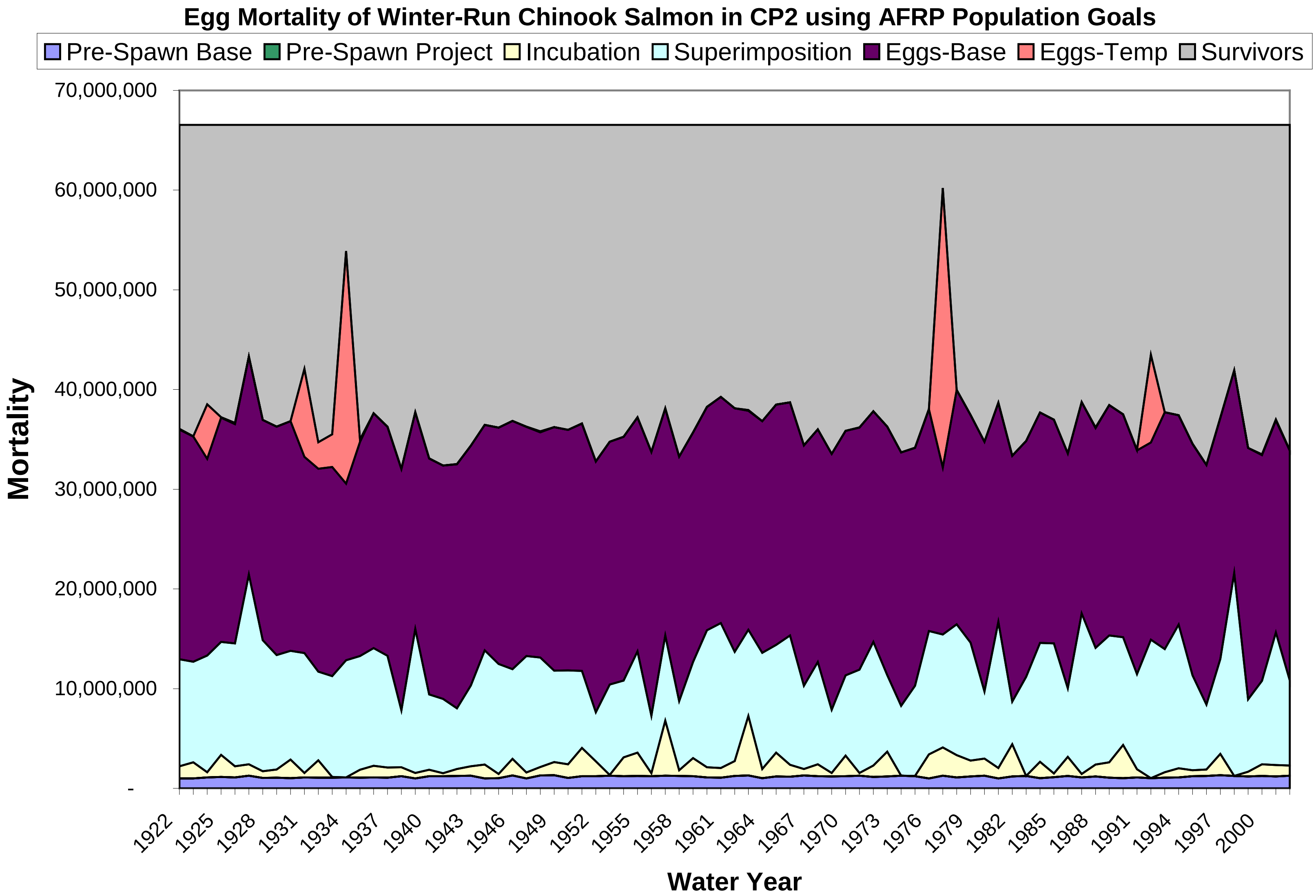

Figure B-4C. Source of mortality of winter-run Chinook salmon eggs in CP2 based on AFRP population goals.

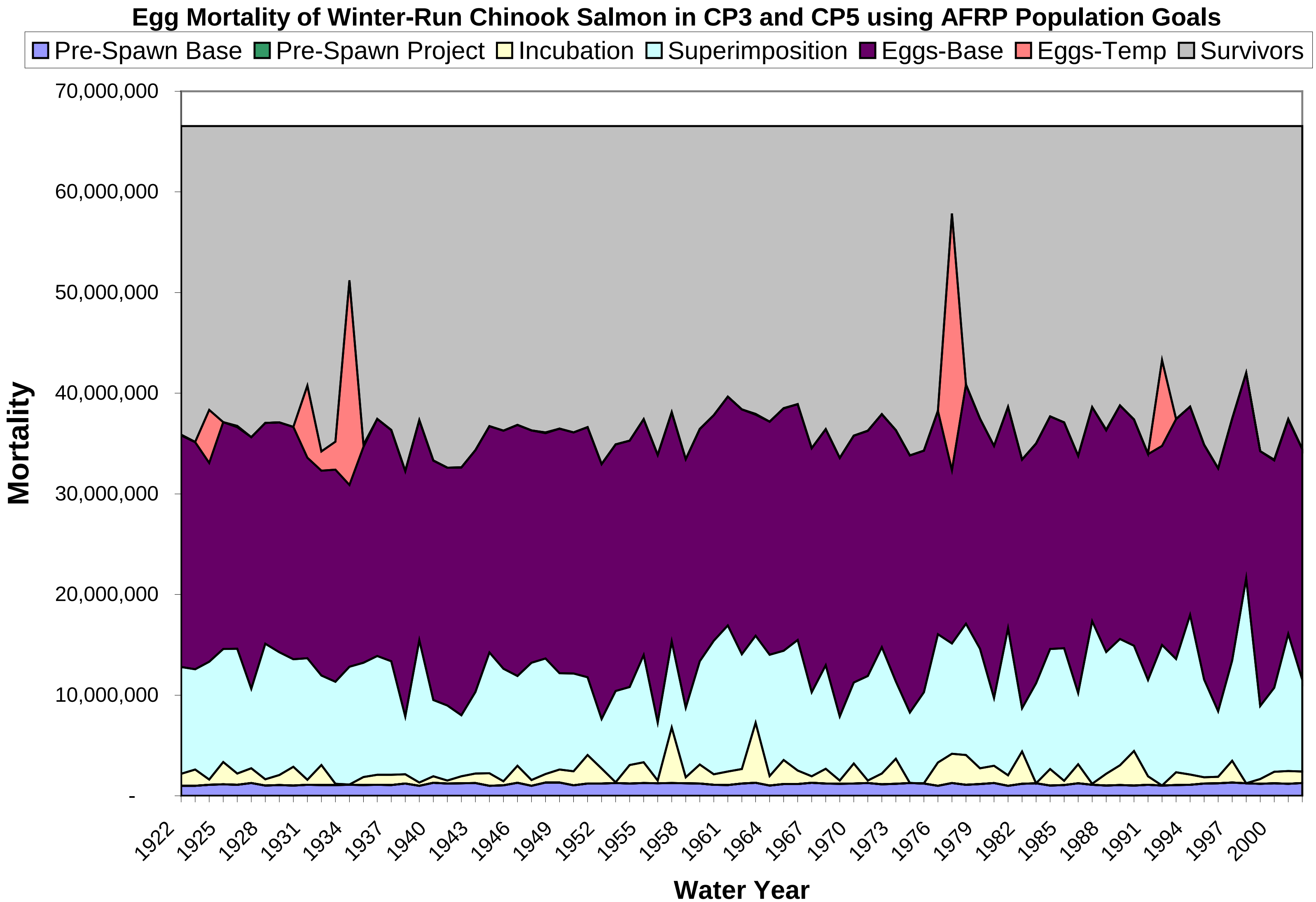

Figure B-4D. Source of mortality of winter-run Chinook salmon eggs in CP3 and CP5 based on AFRP population goals.

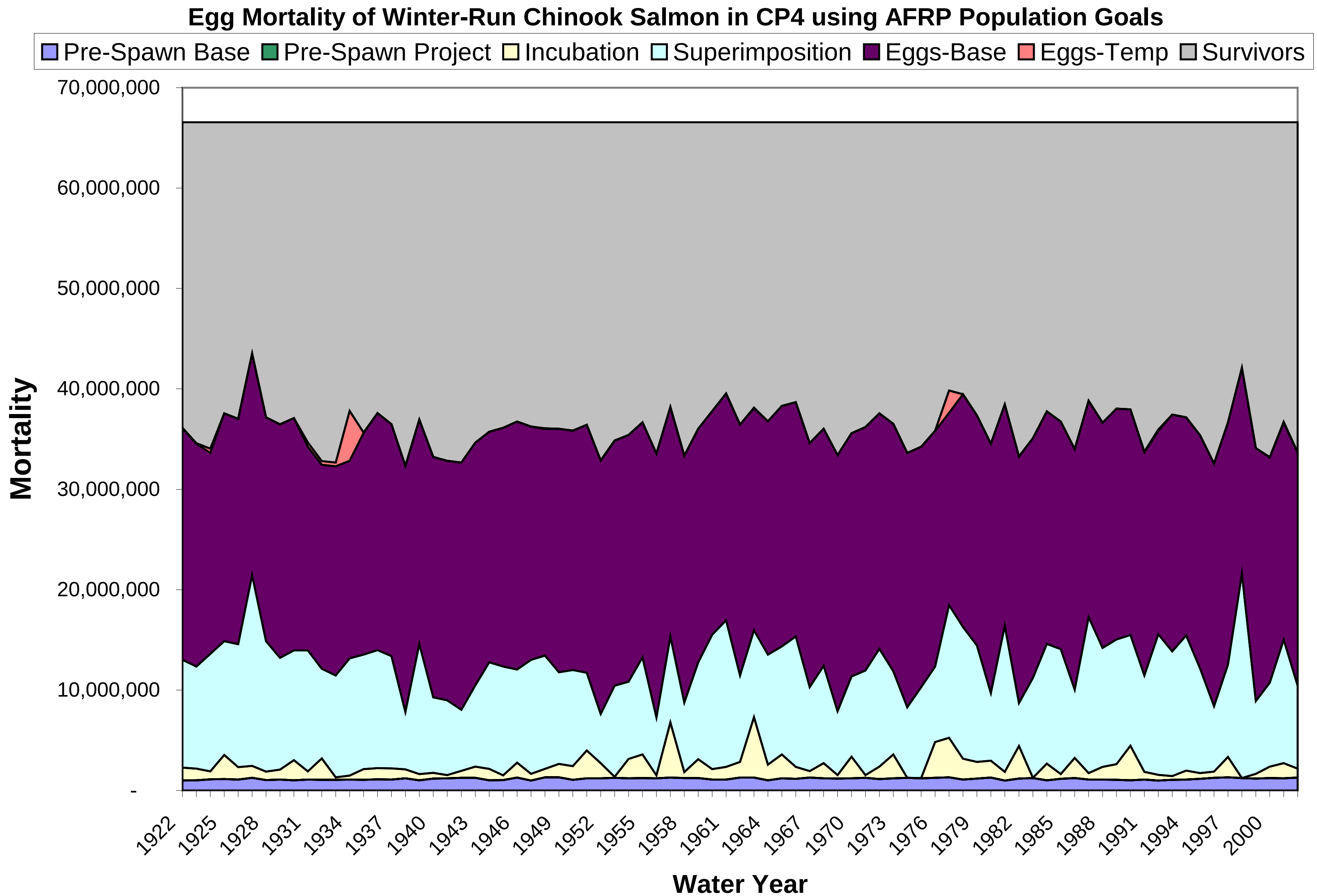

Figure B-4E. Source of mortality of winter-run Chinook salmon eggs in CP4 based on AFRP population goals.

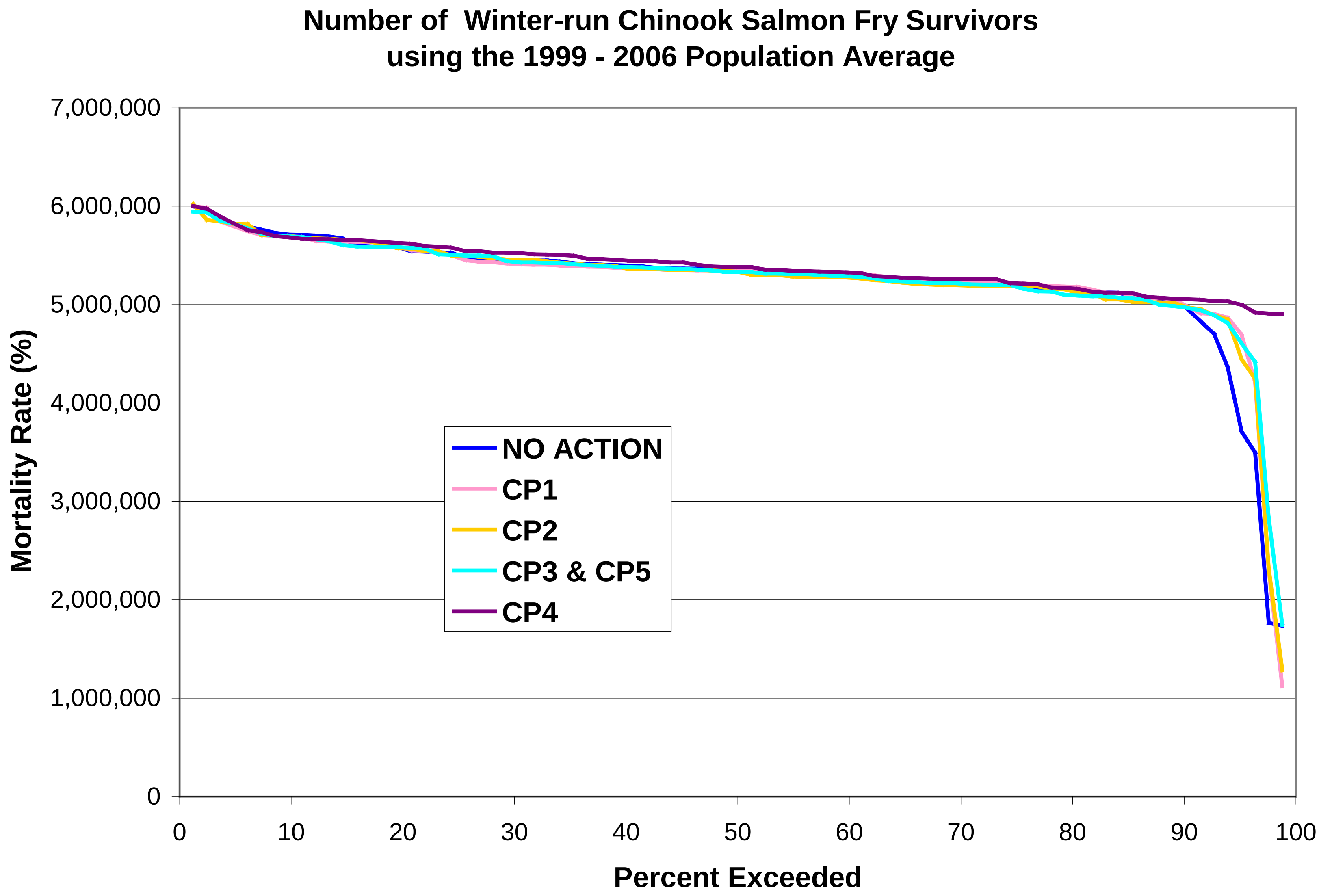

Figure B-5A. Frequency distribution of the number of winter-run Chinook salmon fry survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

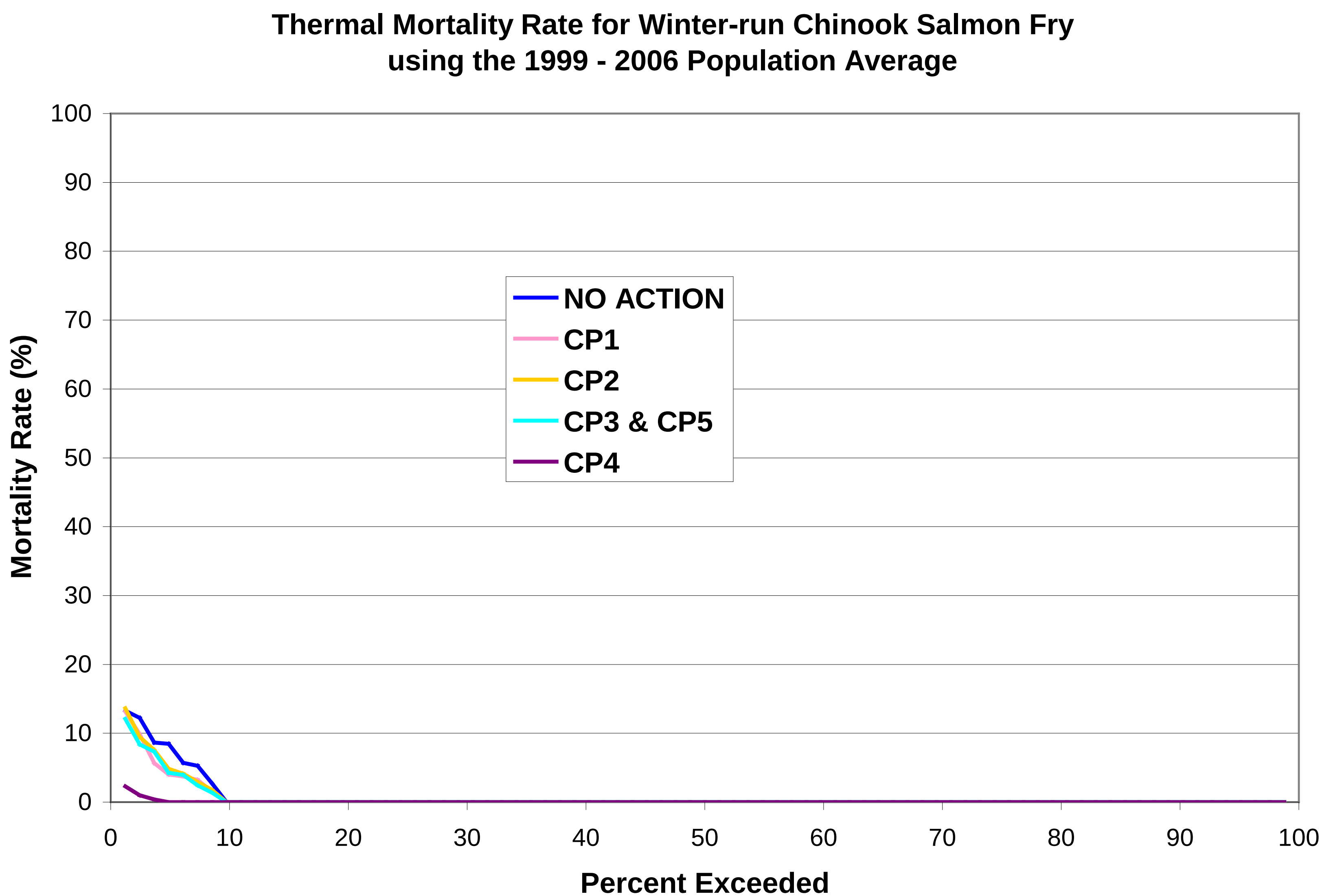

Figure B-5B. Frequency distribution of the thermal mortality rate of winter-run Chinook salmon fry during the 1921-2003 simulation period based on the 1999-2006 population average.

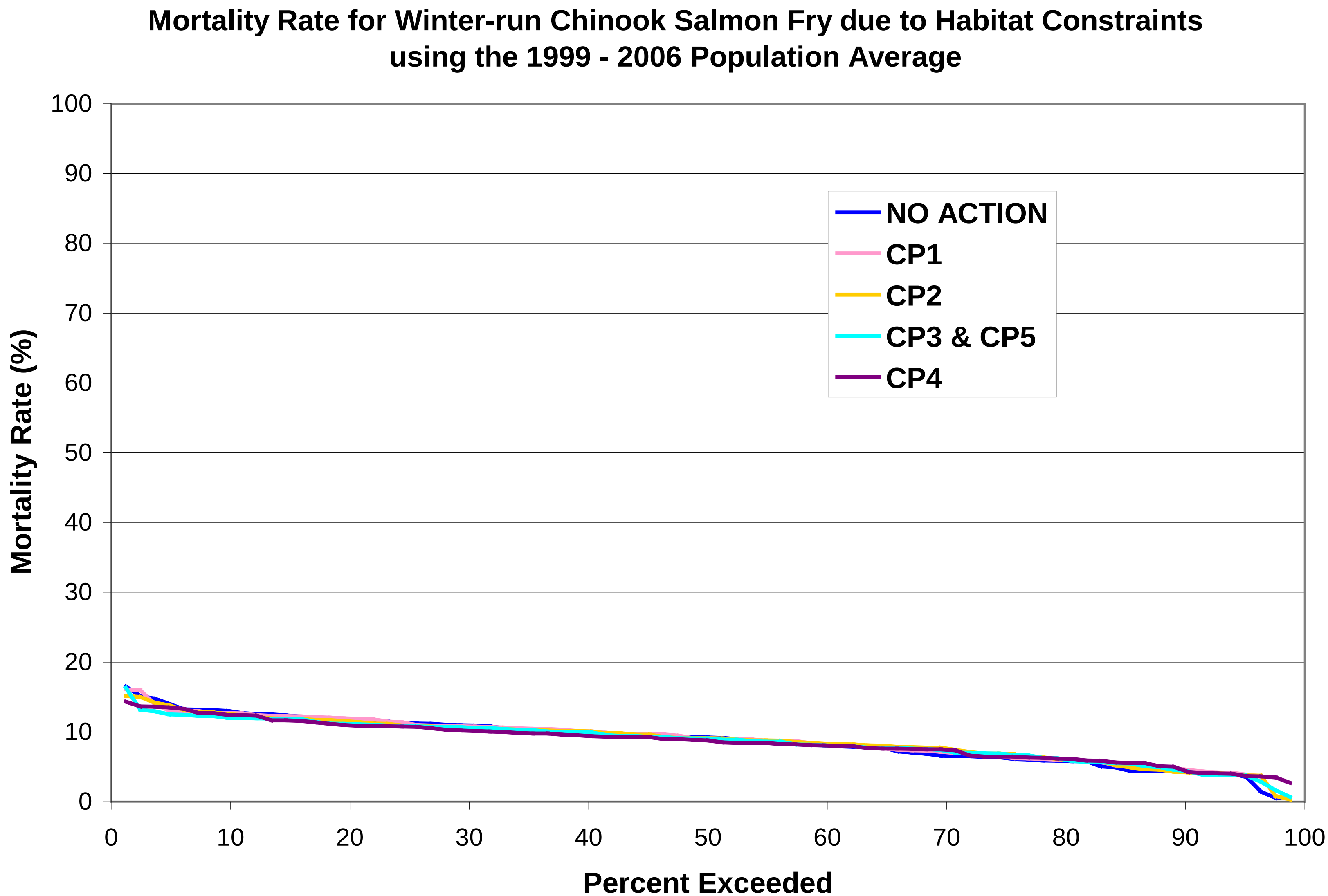

Figure B-5C. Frequency distribution of the mortality rate of winter-run Chinook salmon fry due to habitat constraints (forced movement of fry due to flows or fish density) during the 1921-2003 simulation period based on the 1999-2006 population average.

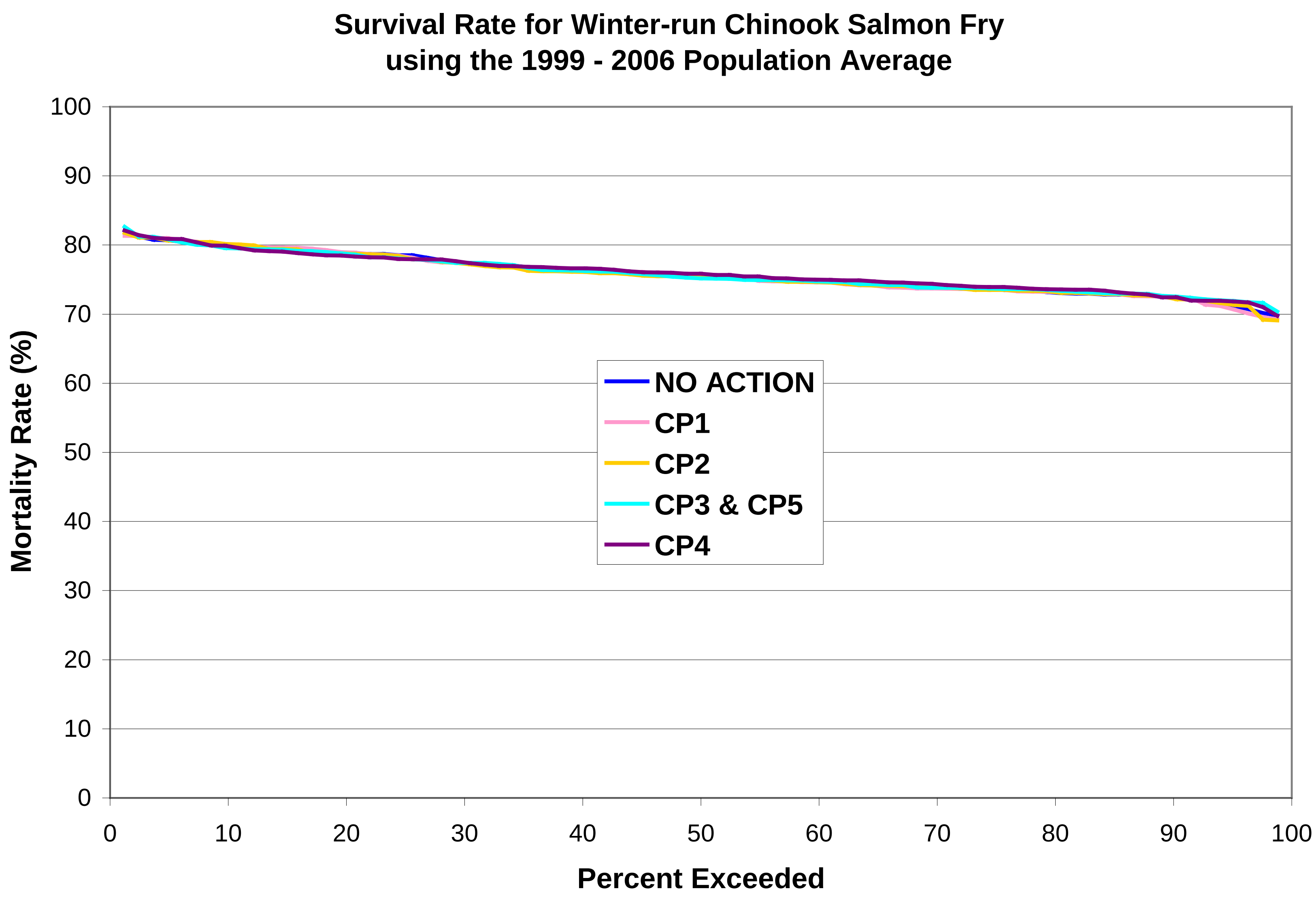

Figure B-5D. Frequency distribution of the survival rate of winter-run Chinook salmon fry during the 1921-2003 simulation period based on the 1999-2006 population average.

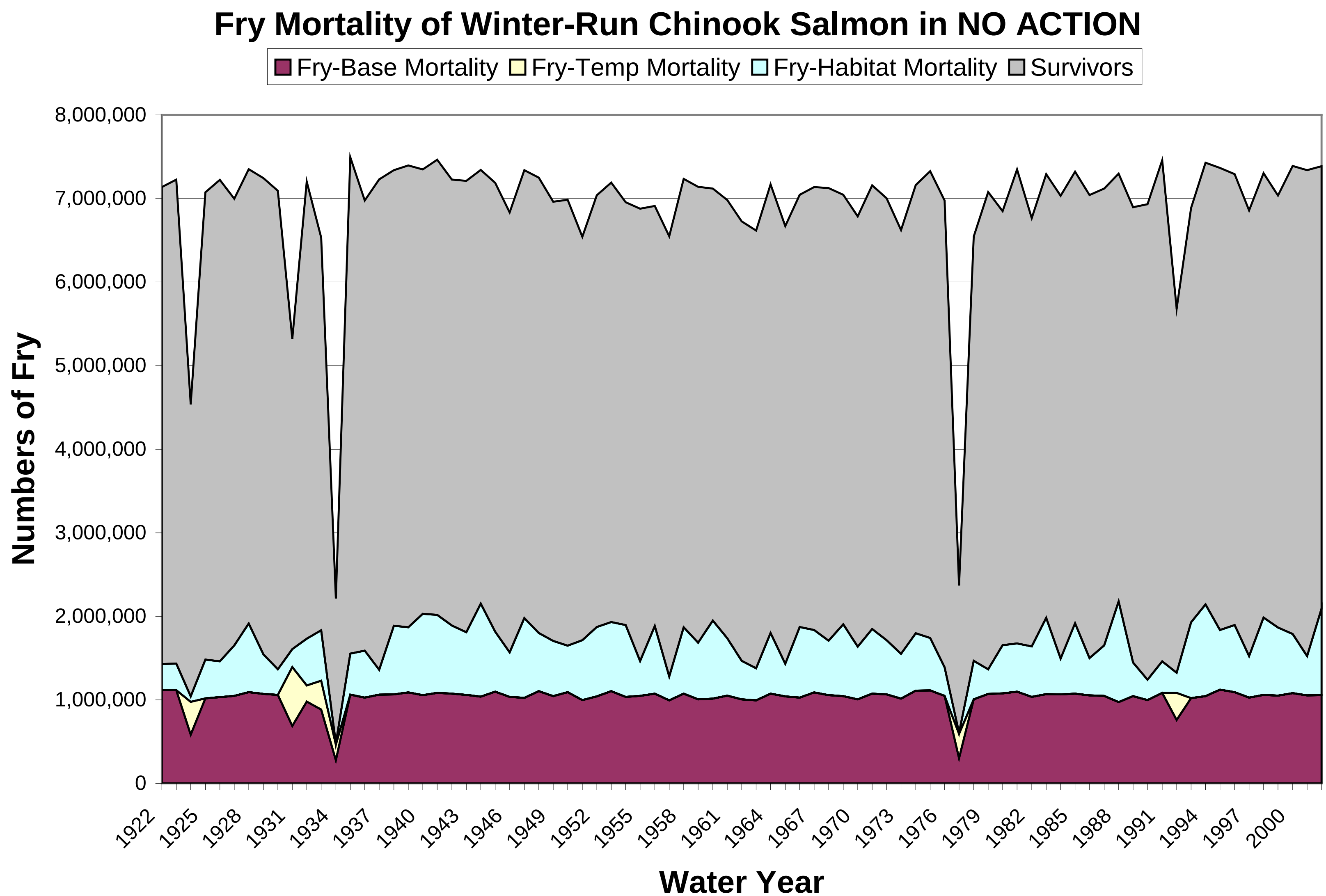

Figure B-6A. Source of mortality of winter-run Chinook salmon fry in NO ACTION based on the 1999 – 2006 population average.

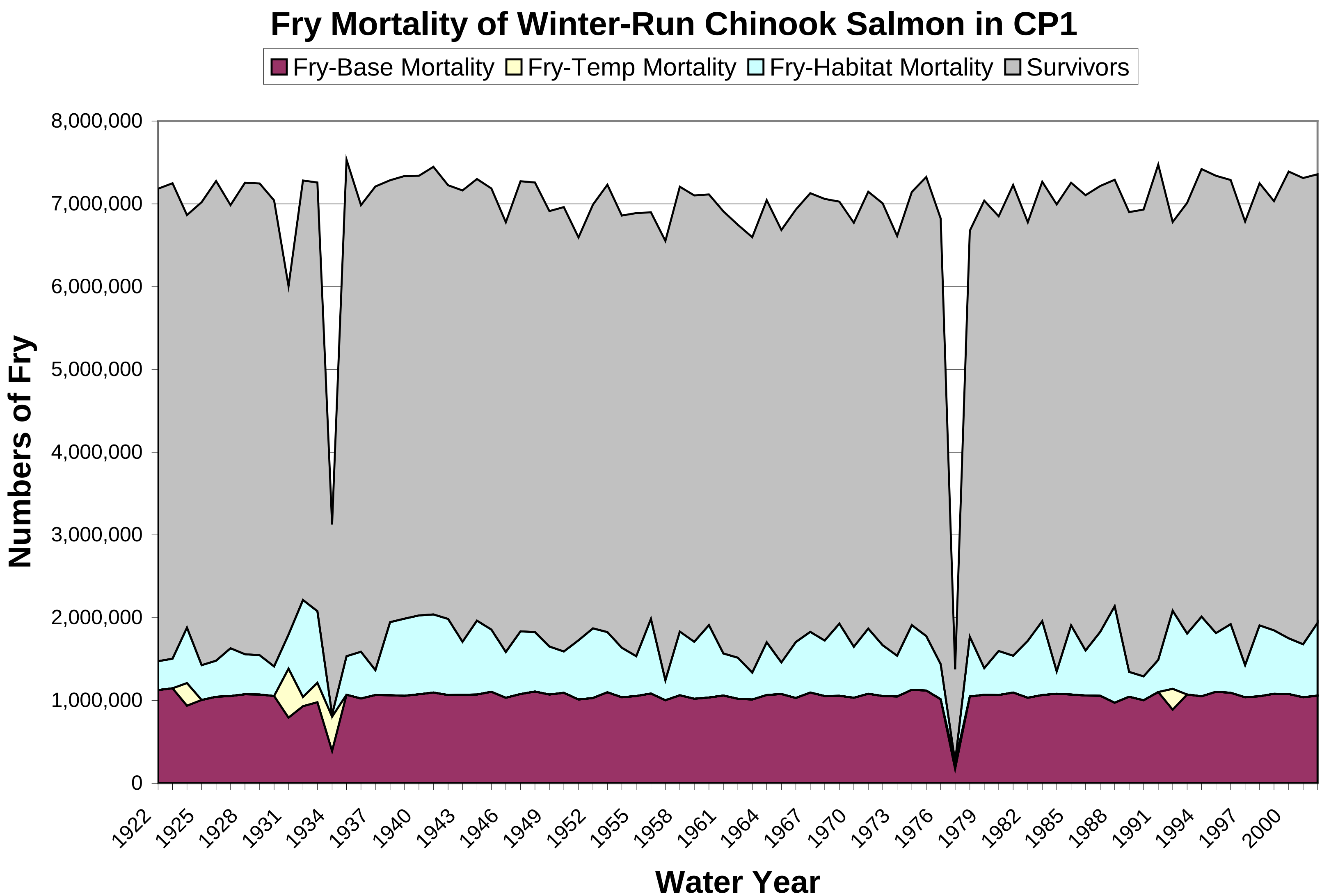

Figure B-6B. Source of mortality of winter-run Chinook salmon fry in CP1 based on the 1999 – 2006 population average.

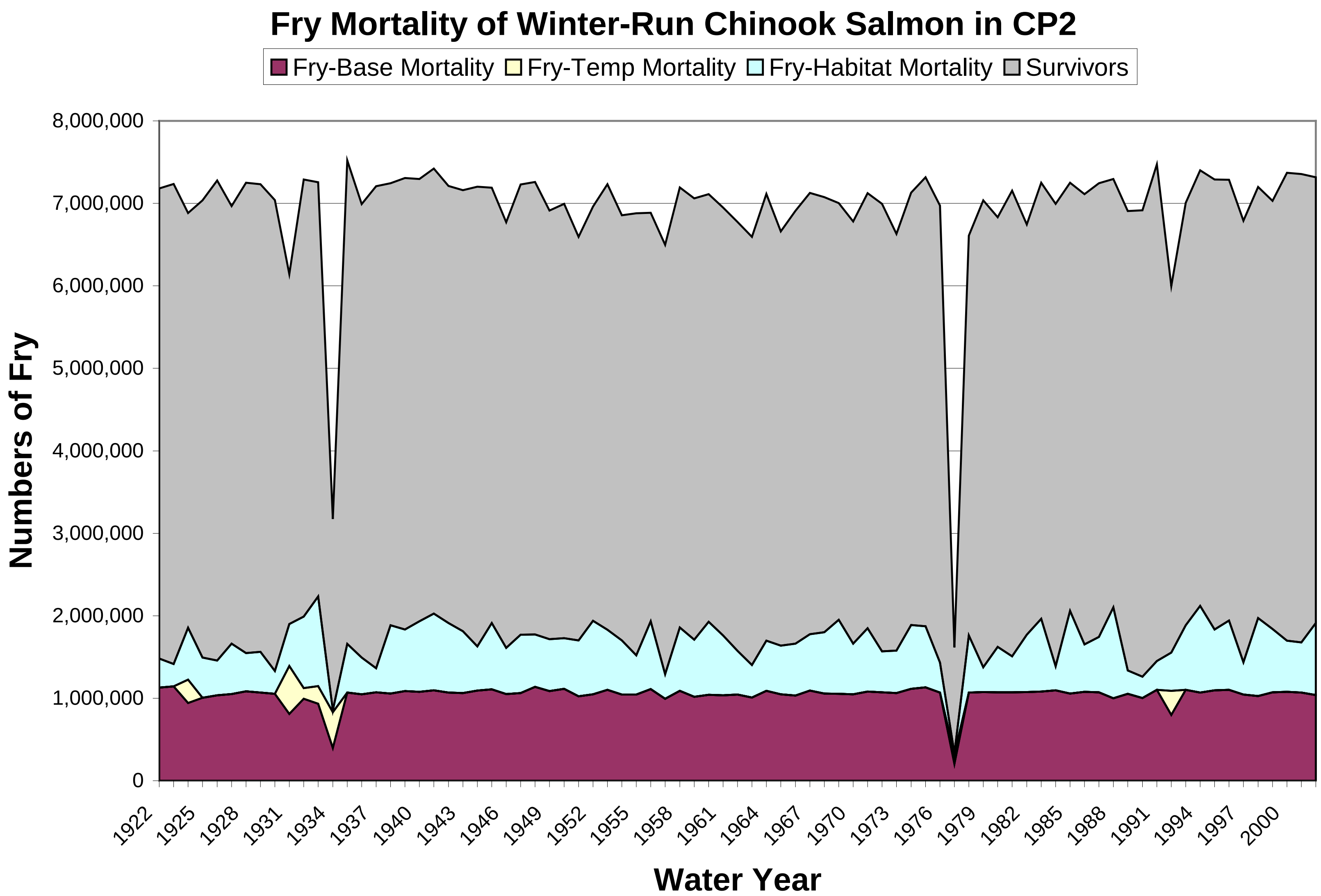

Figure B-6C. Source of mortality of winter-run Chinook salmon fry in CP2 based on the 1999 – 2006 population average.

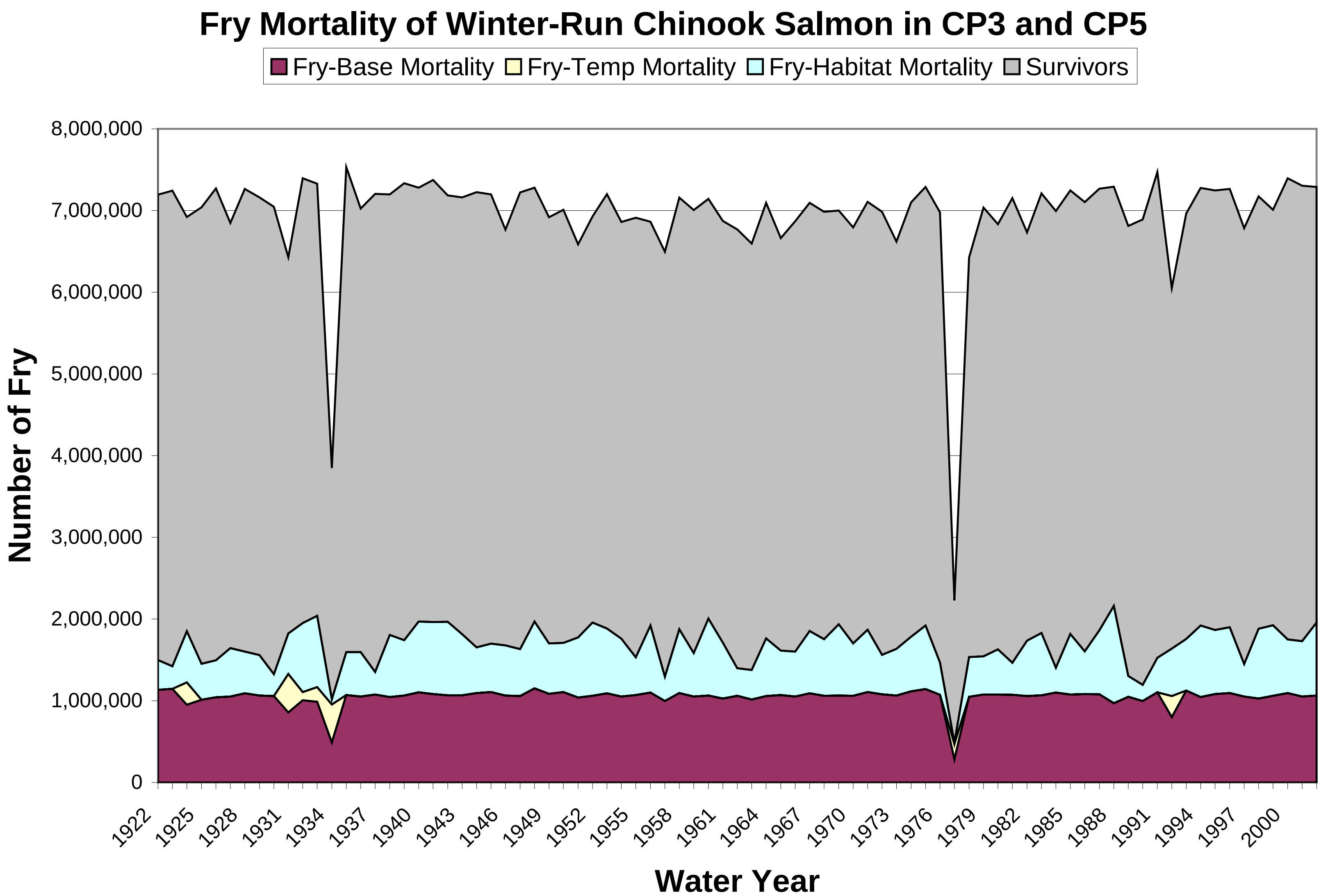

Figure B-6D. Source of mortality of winter-run Chinook salmon fry in CP3 and CP5 based on the 1999 – 2006 population average.

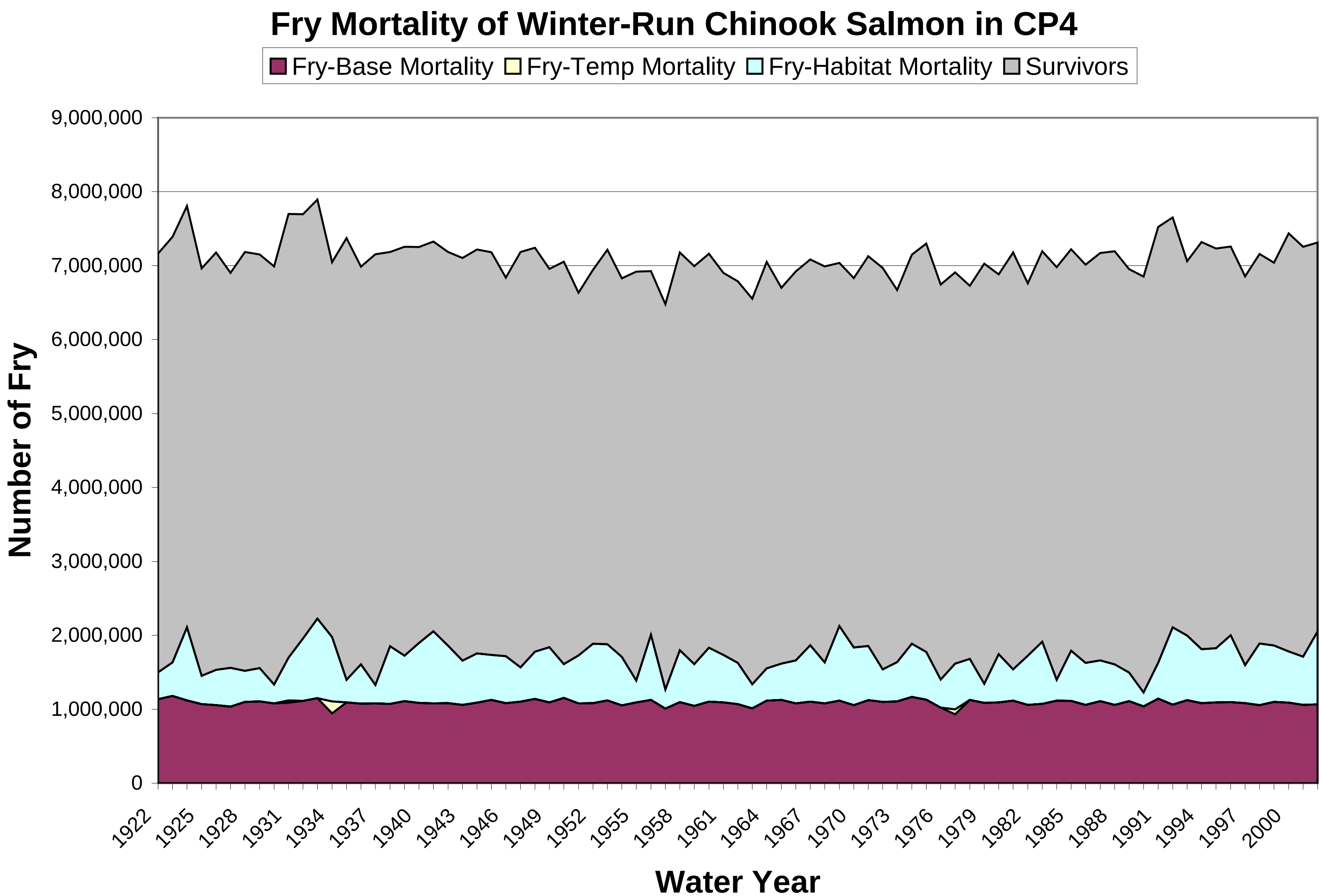

Figure B-6E. Source of mortality of winter-run Chinook salmon fry in CP4 based on the 1999 – 2006 population average.

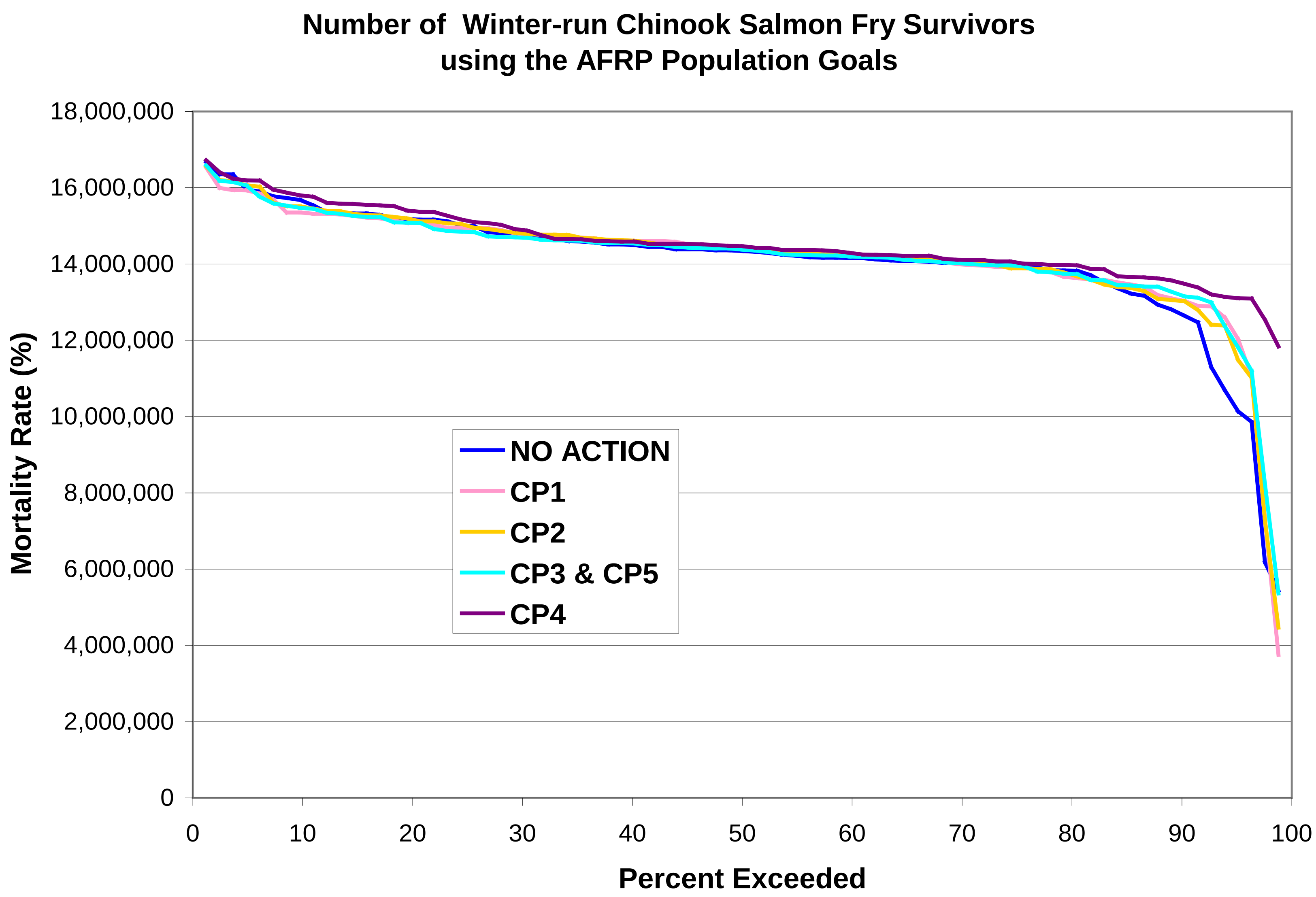

Figure B-7A. Frequency distribution of the number of winter-run Chinook salmon fry survivors during the 1921-2003 simulation period based on the AFRP population goals.

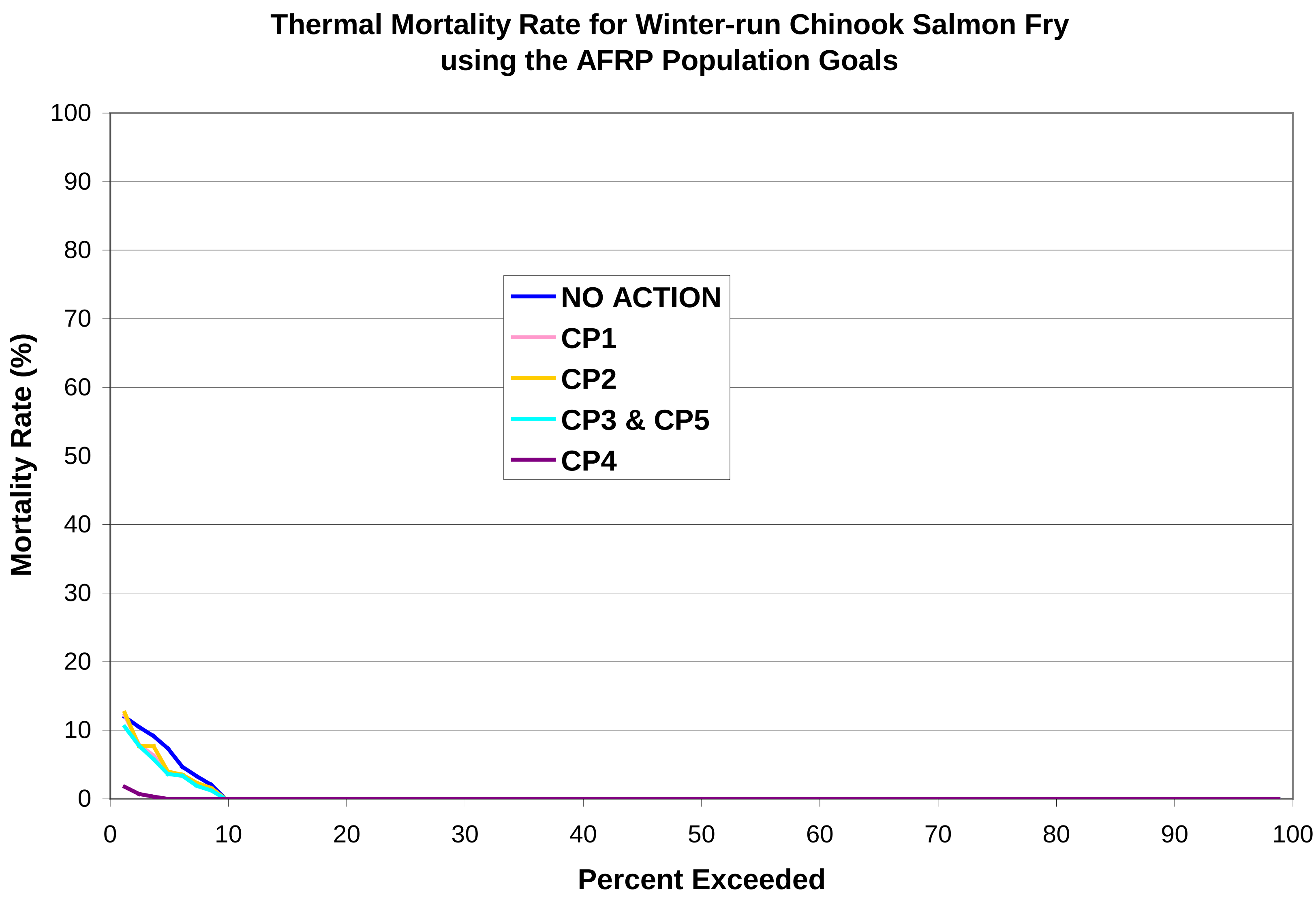

Figure B-7B. Frequency distribution of the thermal mortality rate of winter-run Chinook salmon fry during the 1921-2003 simulation period based on the AFRP population goals.

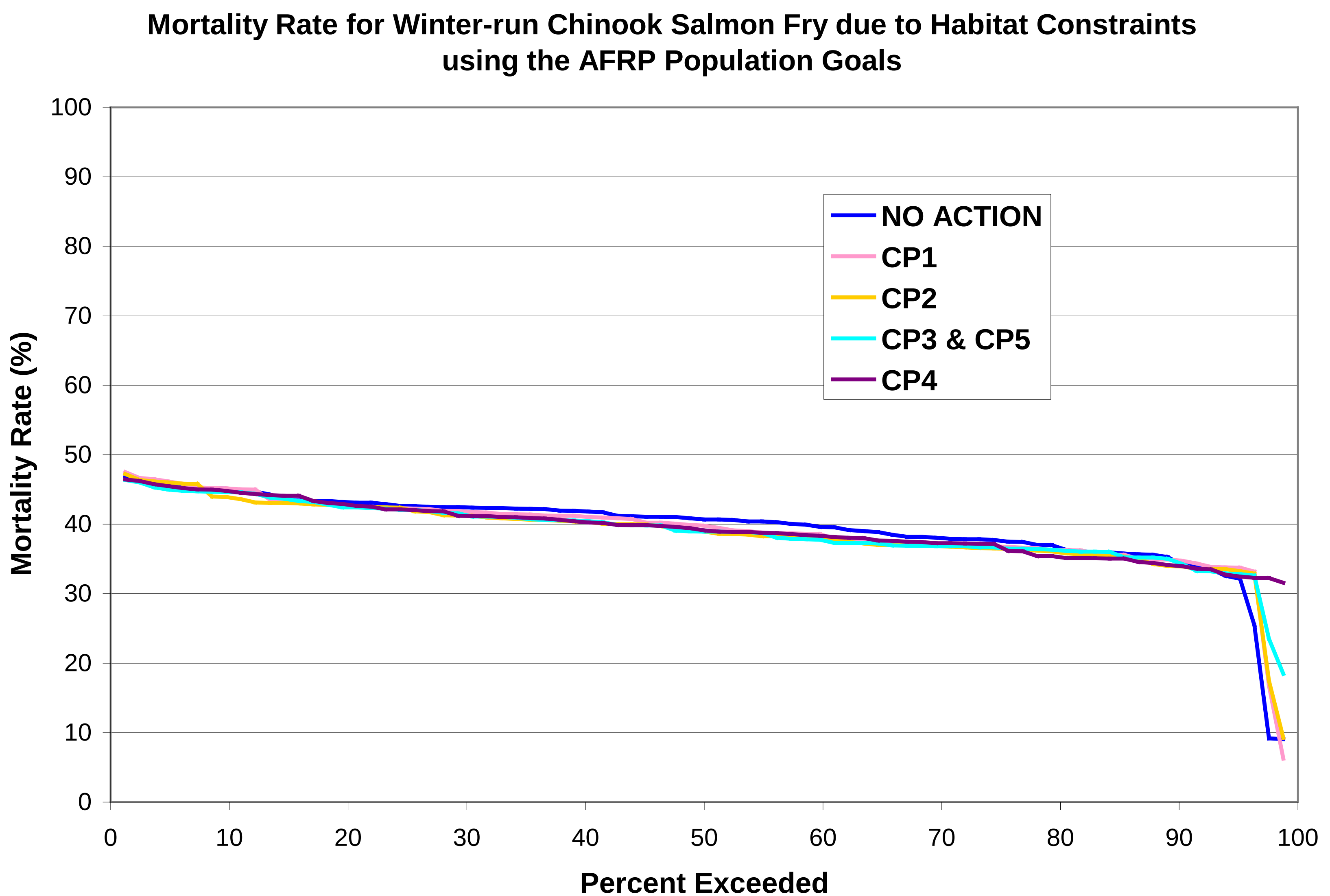

Figure B-7C. Frequency distribution of the mortality rate of winter-run Chinook salmon fry due to habitat constraints (forced movement of fry due to flows or fish density) during the 1921-2003 simulation period based on the AFRP population goals.

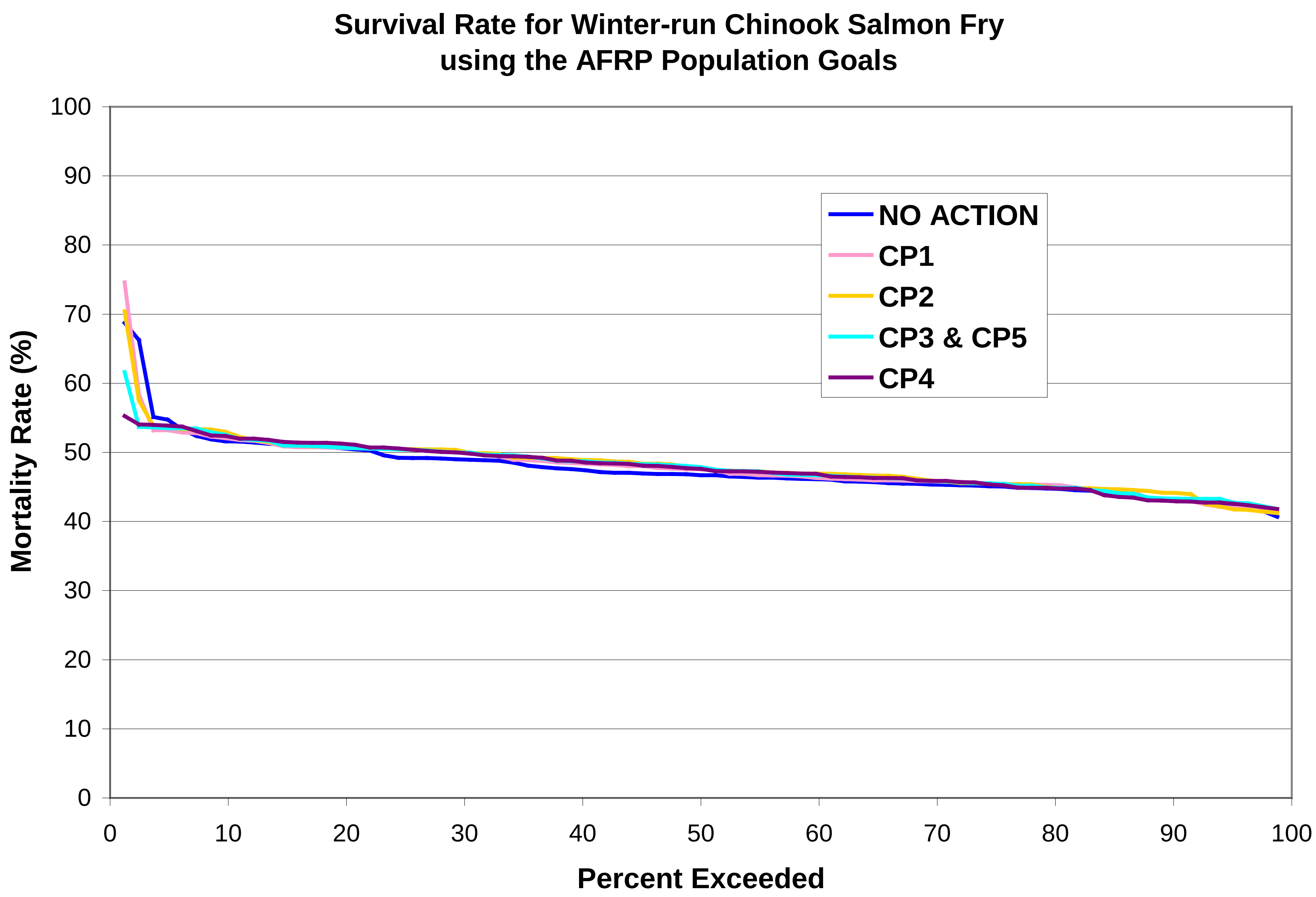

Figure B-7D. Frequency distribution of the survival rate of winter-run Chinook salmon fry during the 1921-2003 simulation period based on the AFRP population goals.

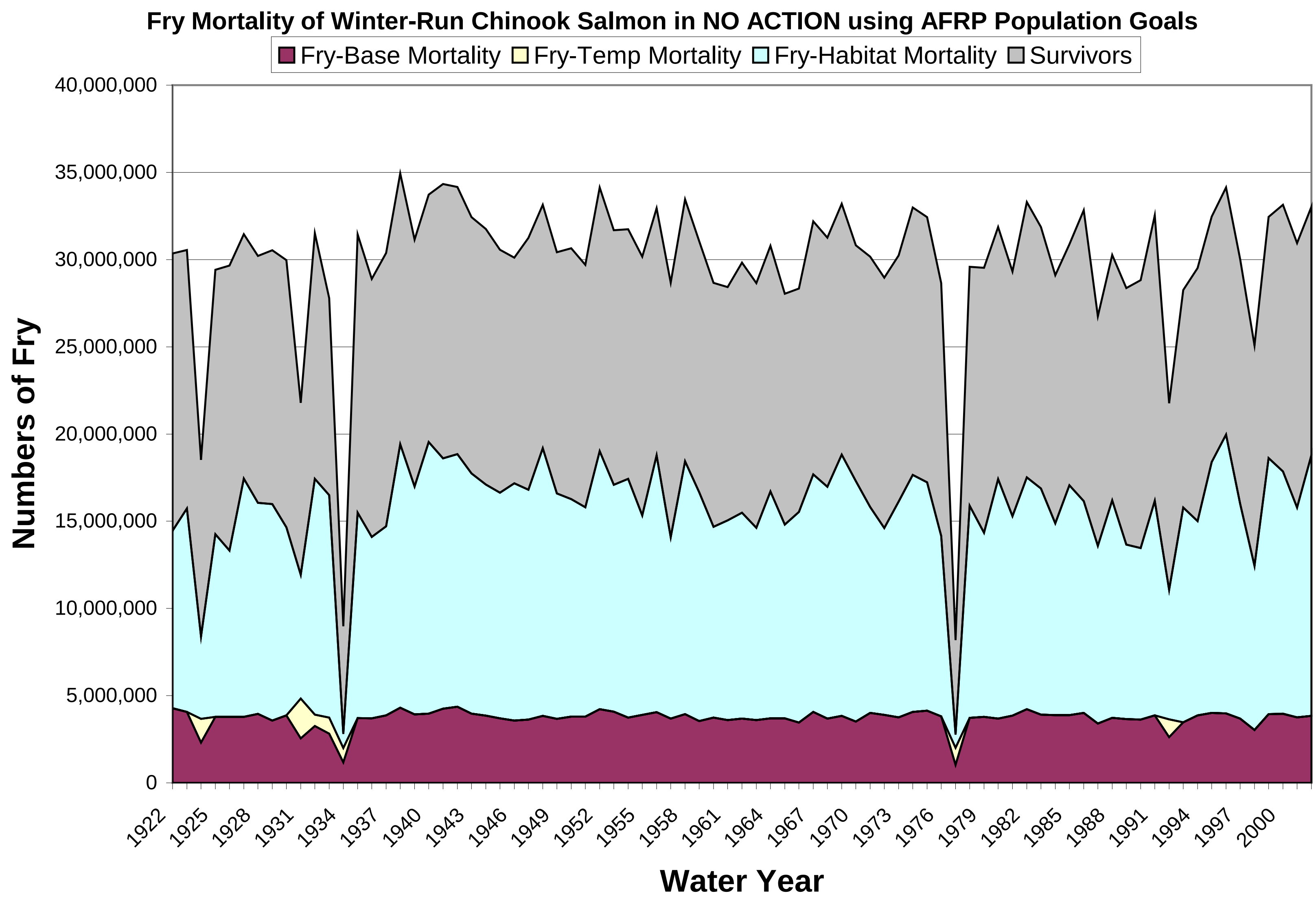

Figure B-8A. Source of mortality of winter-run Chinook salmon fry in NO ACTION based on AFRP population goals.

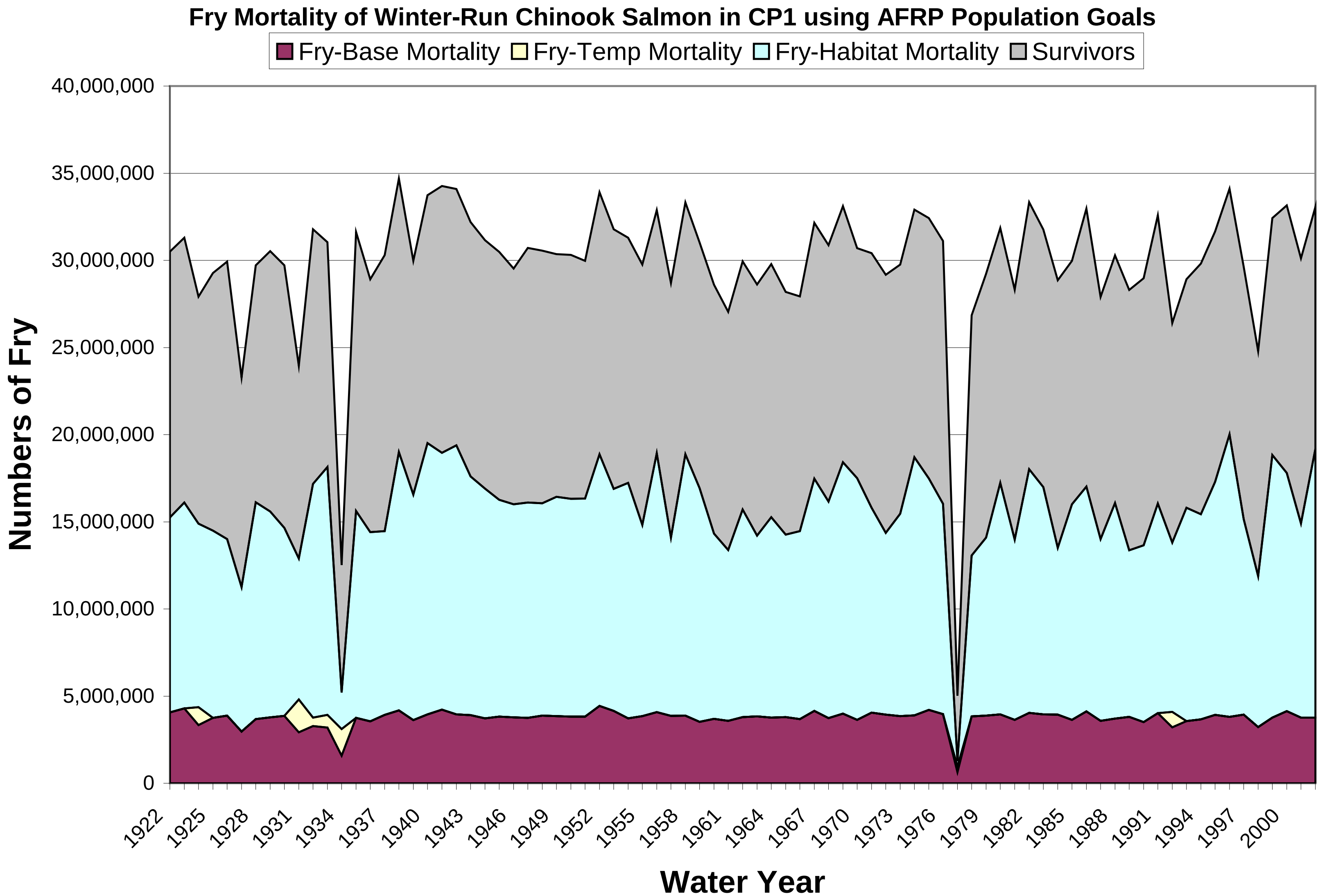

Figure B-8B. Source of mortality of winter-run Chinook salmon fry in CP1 based on AFRP population goals.

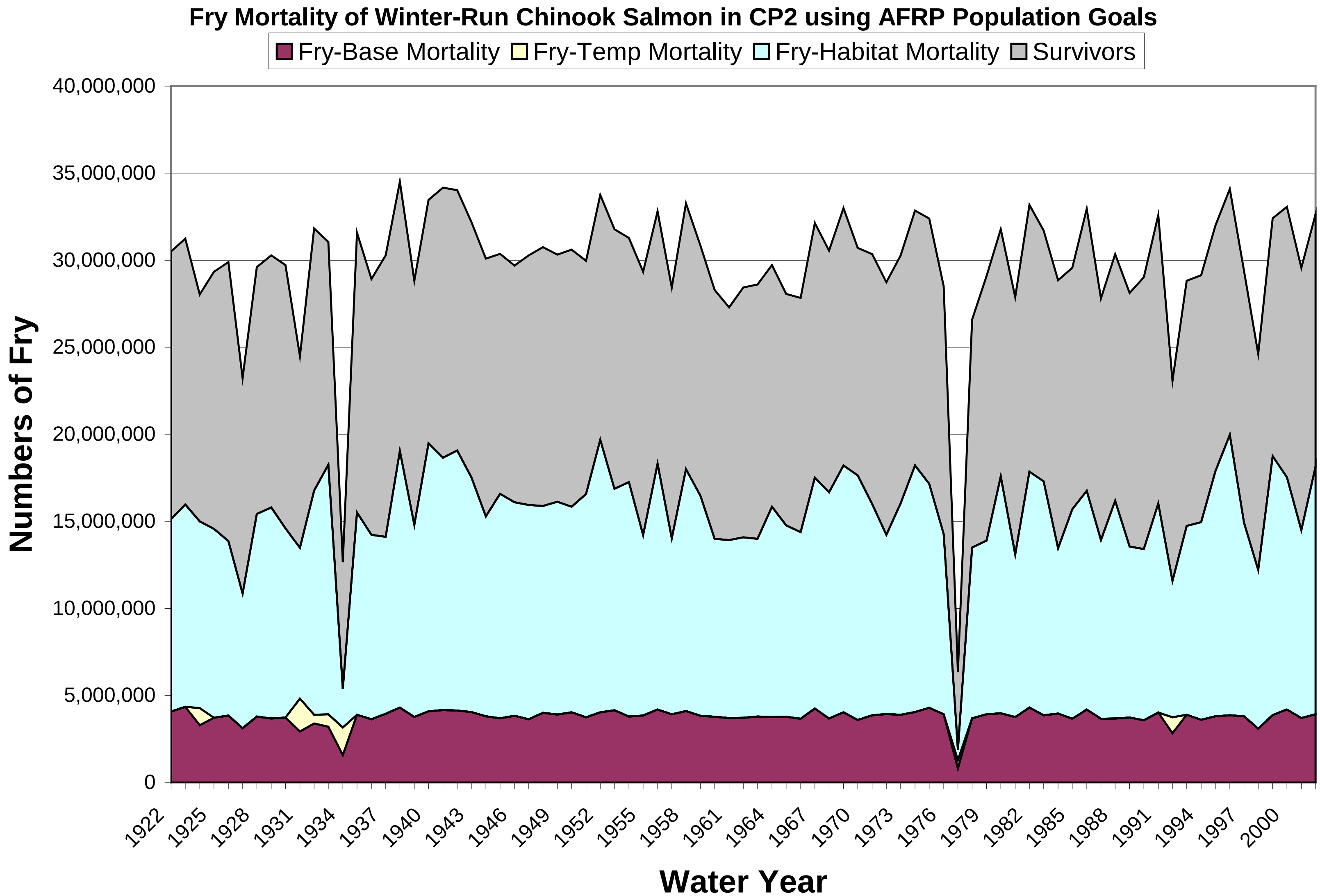

Figure B-8C. Source of mortality of winter-run Chinook salmon fry in CP2 based on AFRP population goals.

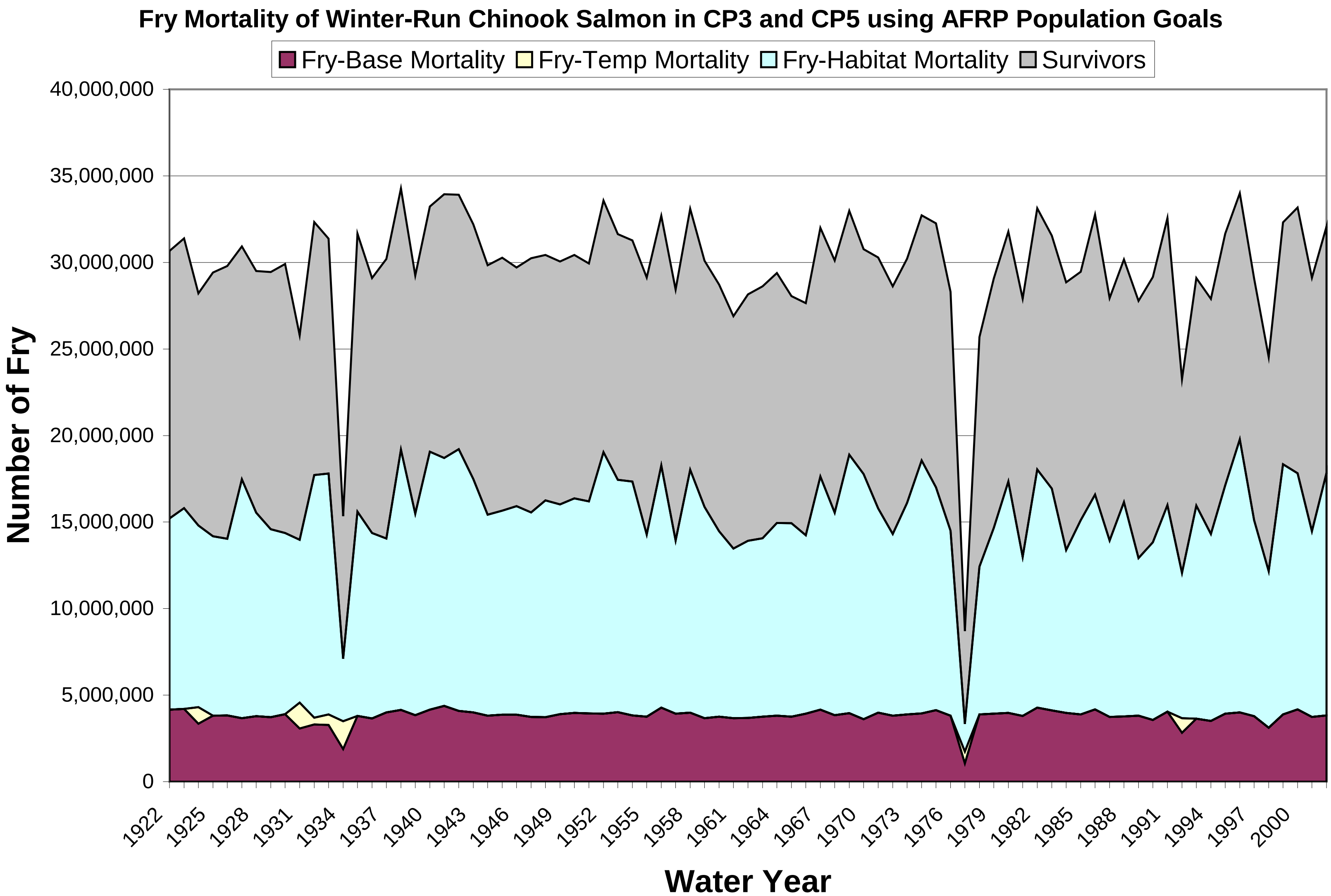

Figure B-8D. Source of mortality of winter-run Chinook salmon fry in CP3 and CP5 based on AFRP population goals.

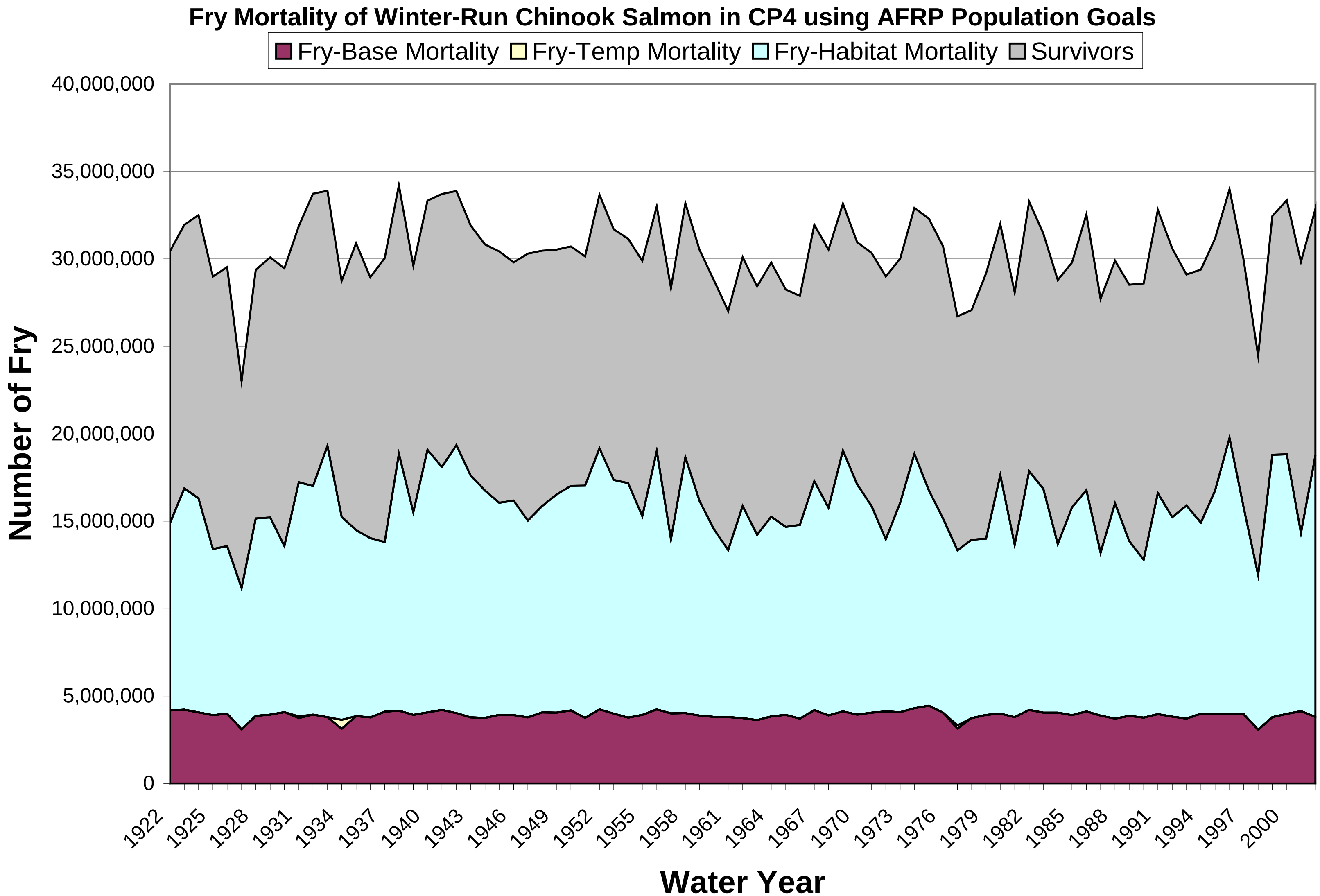

Figure B-8E. Source of mortality of winter-run Chinook salmon fry in CP4 based on AFRP population goals.

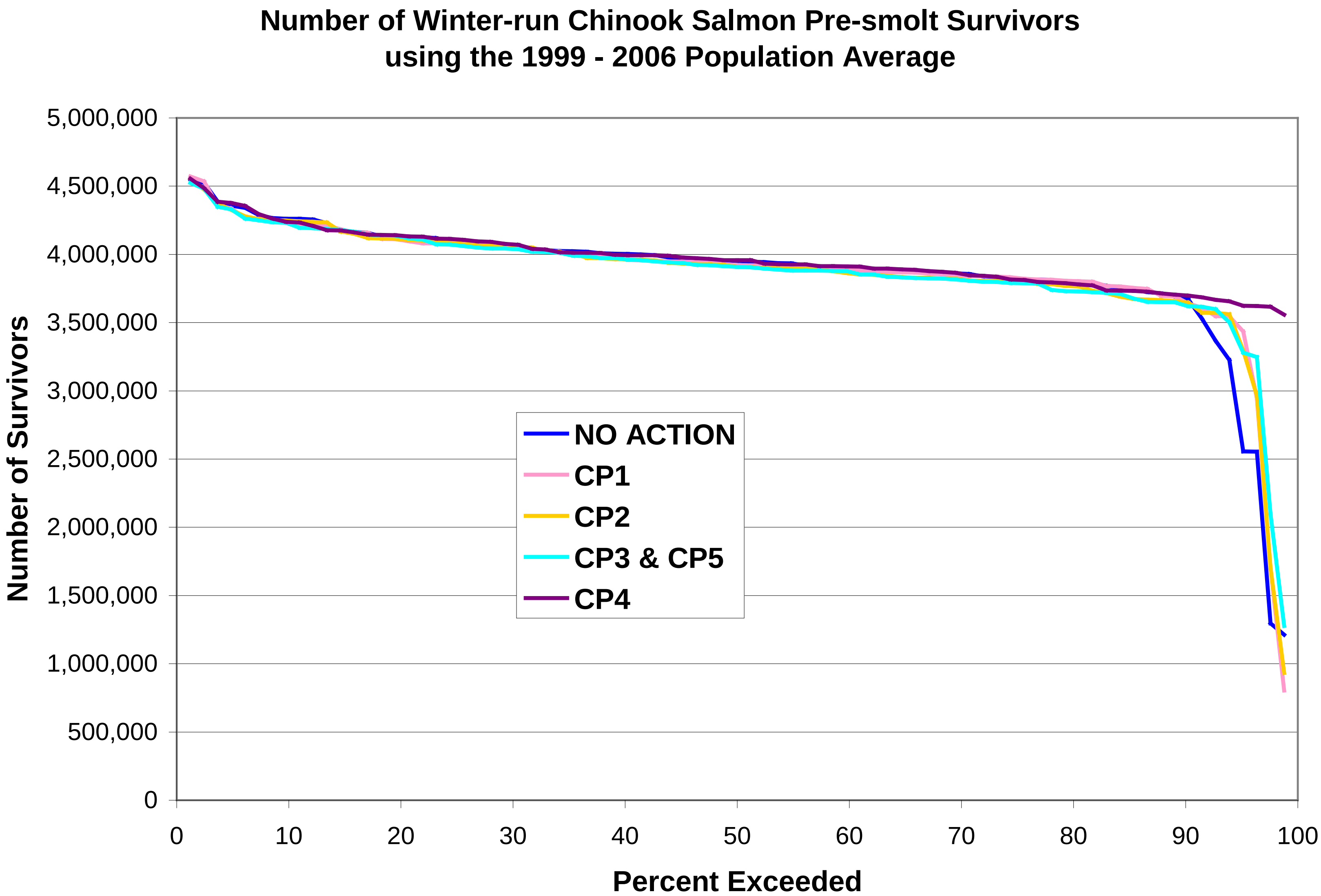

Figure B-9A. Frequency distribution of the number of winter-run Chinook salmon pre-smolt survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

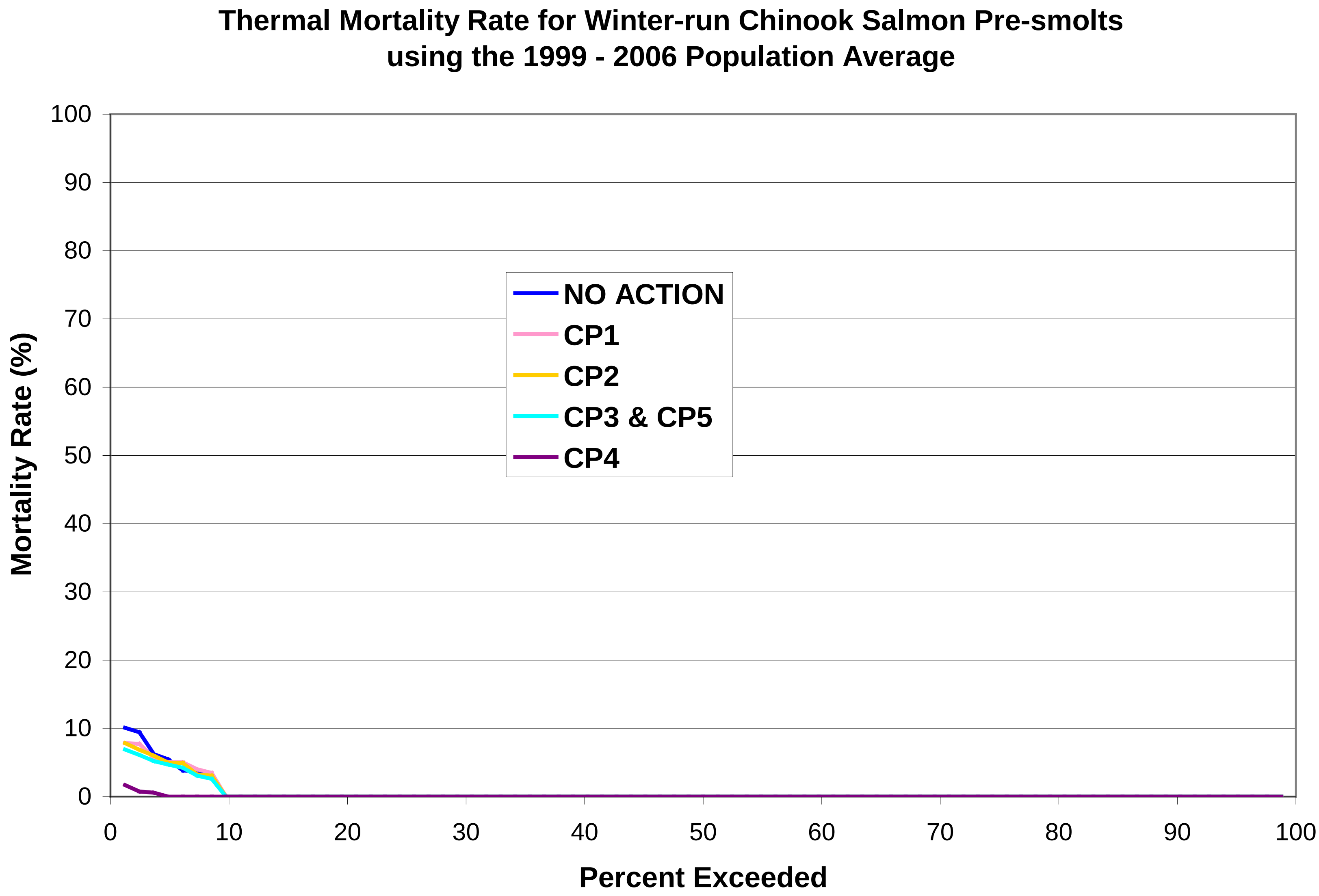

Figure B-9B. Frequency distribution of the thermal mortality rate of winter-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the 1999-2006 population average.

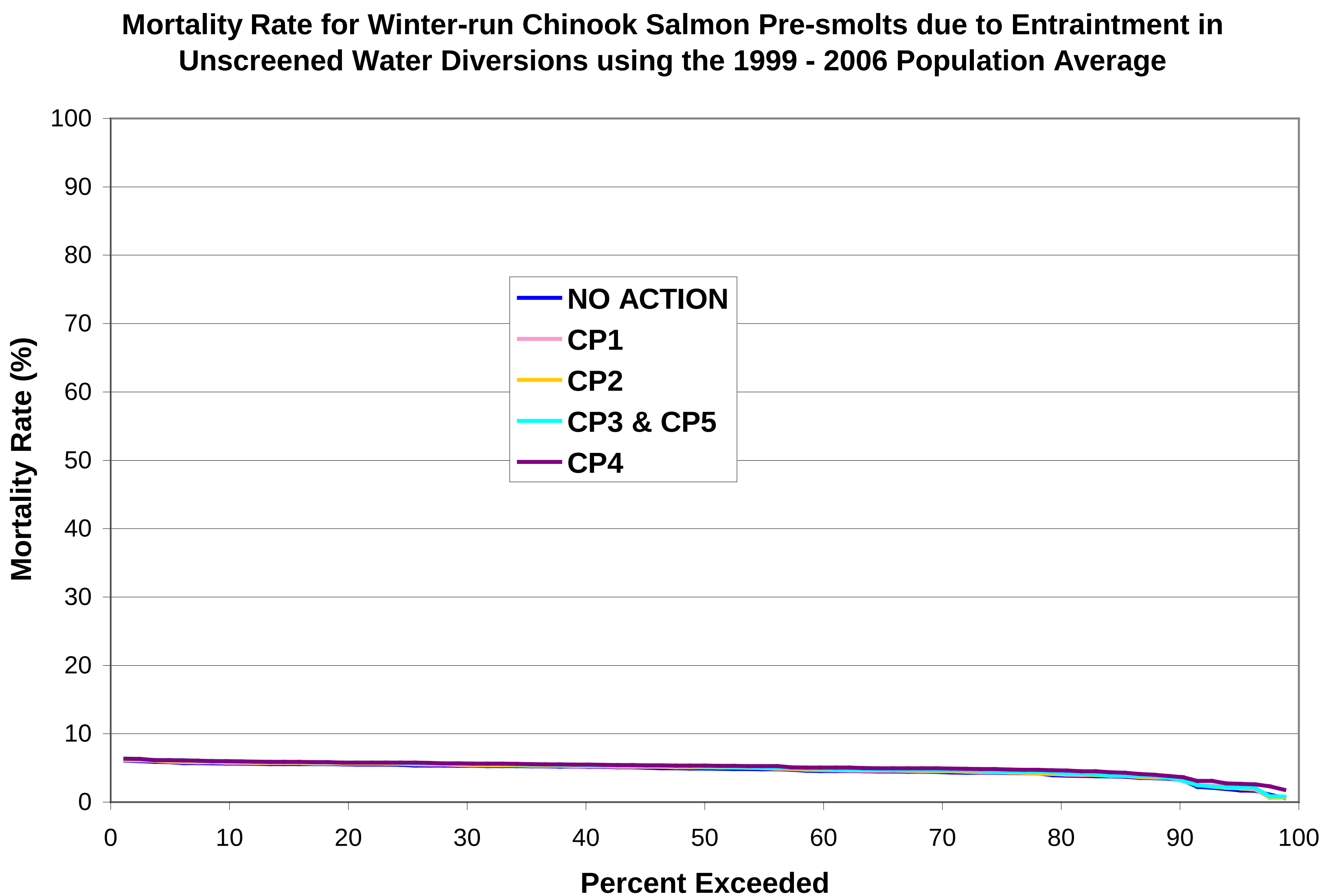

Figure B-9C. Frequency distribution of the mortality rate of winter-run Chinook salmon pre-smolts due to entrainment in unscreened water diversions during the 1921-2003 simulation period based on the 1999-2006 population average.

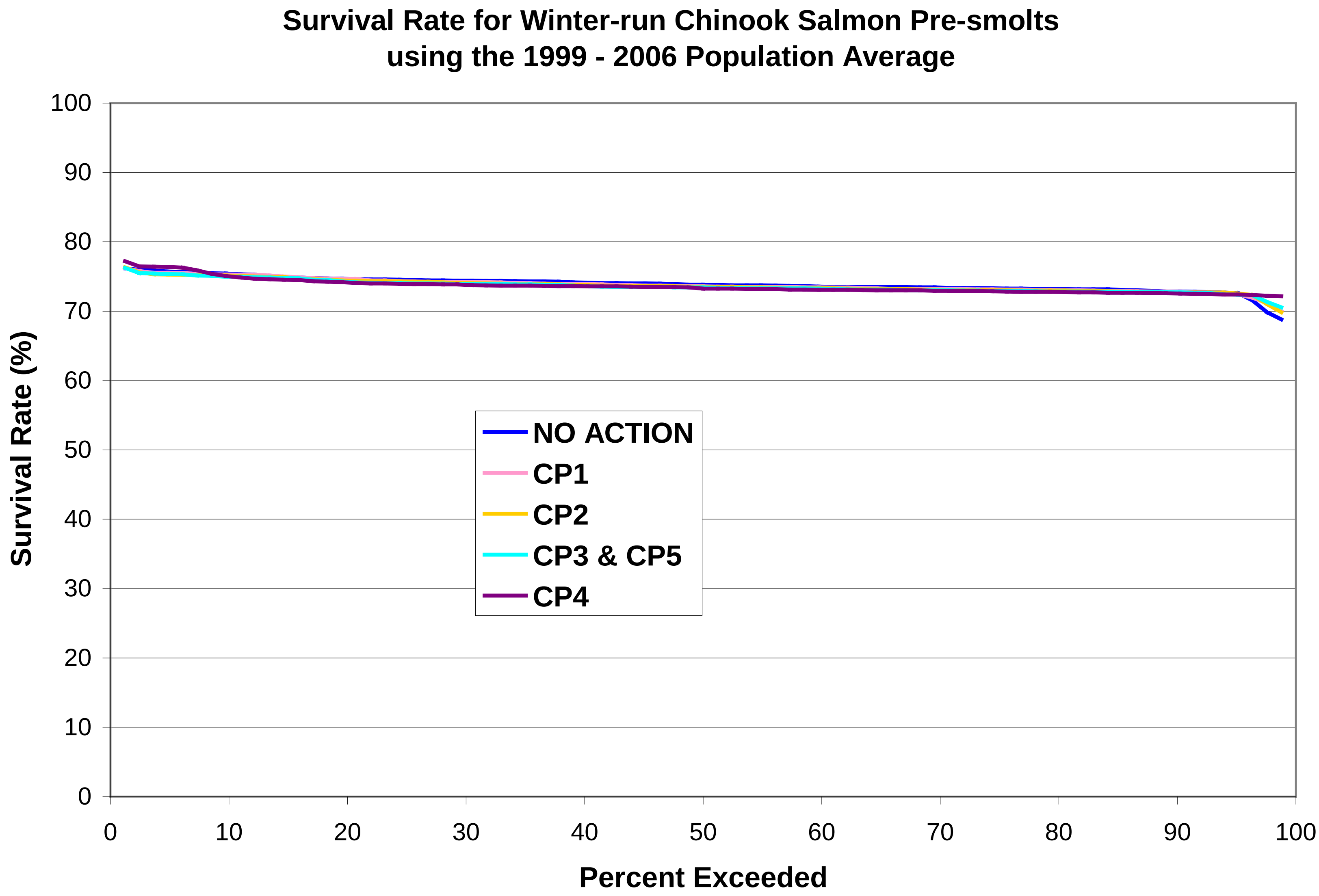

Figure B-9D. Frequency distribution of the survival rate of winter-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the 1999-2006 population average.

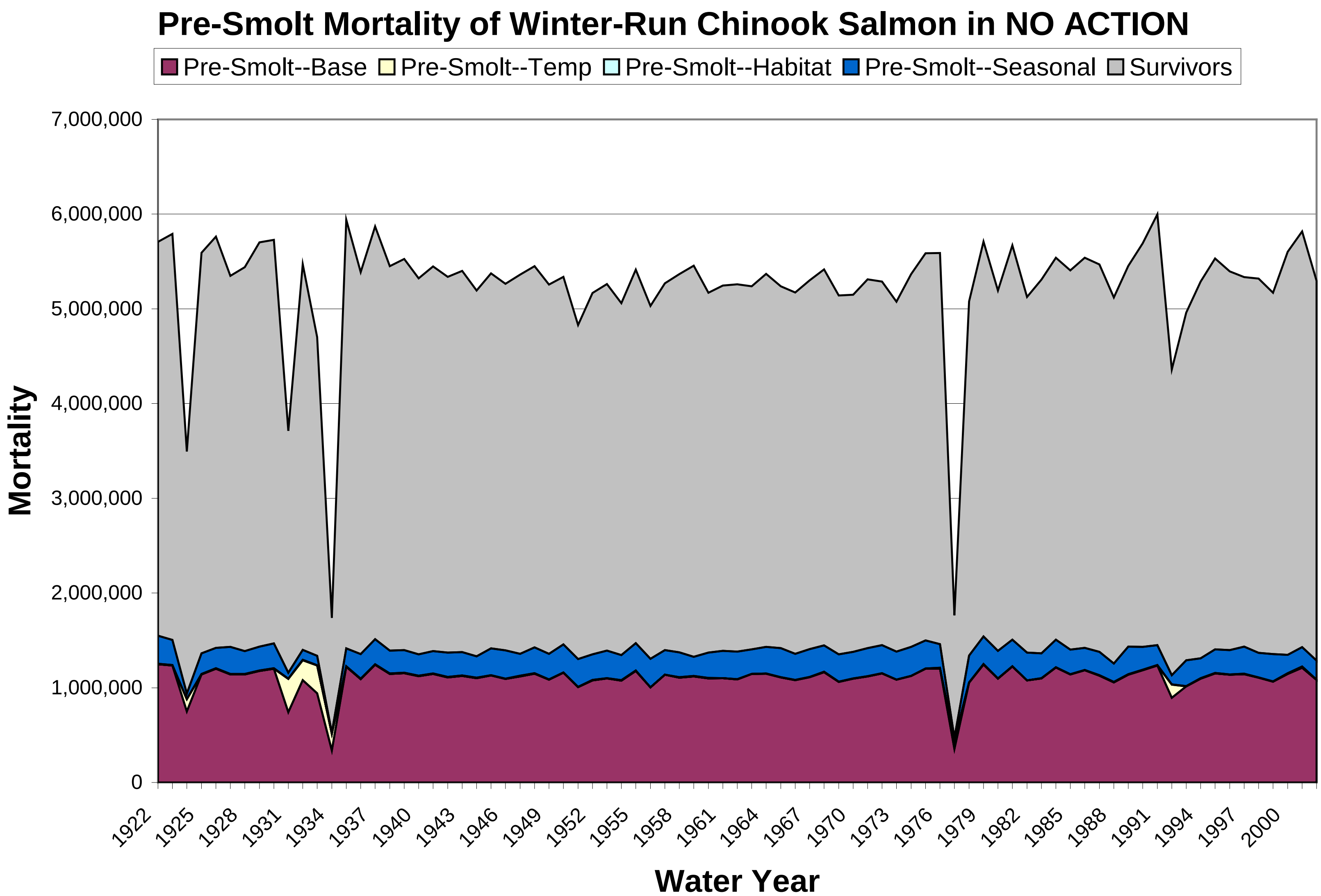

Figure B-10A. Source of mortality of winter-run Chinook salmon pre-smolts in NO ACTION based on the 1999-2006 population average.

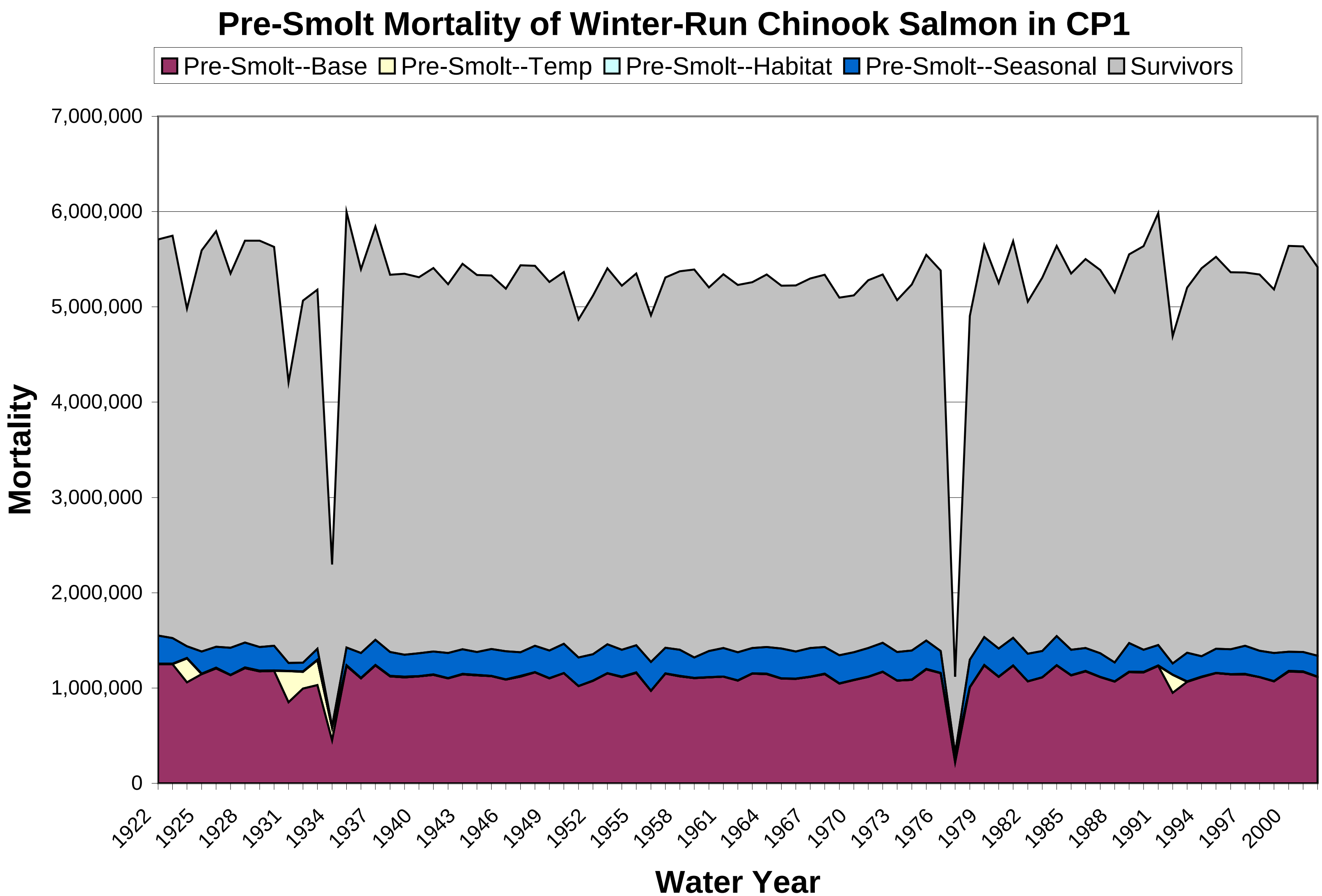

Figure B-10B. Source of mortality of winter-run Chinook salmon pre-smolts in CP1 based on the 1999-2006 population average.

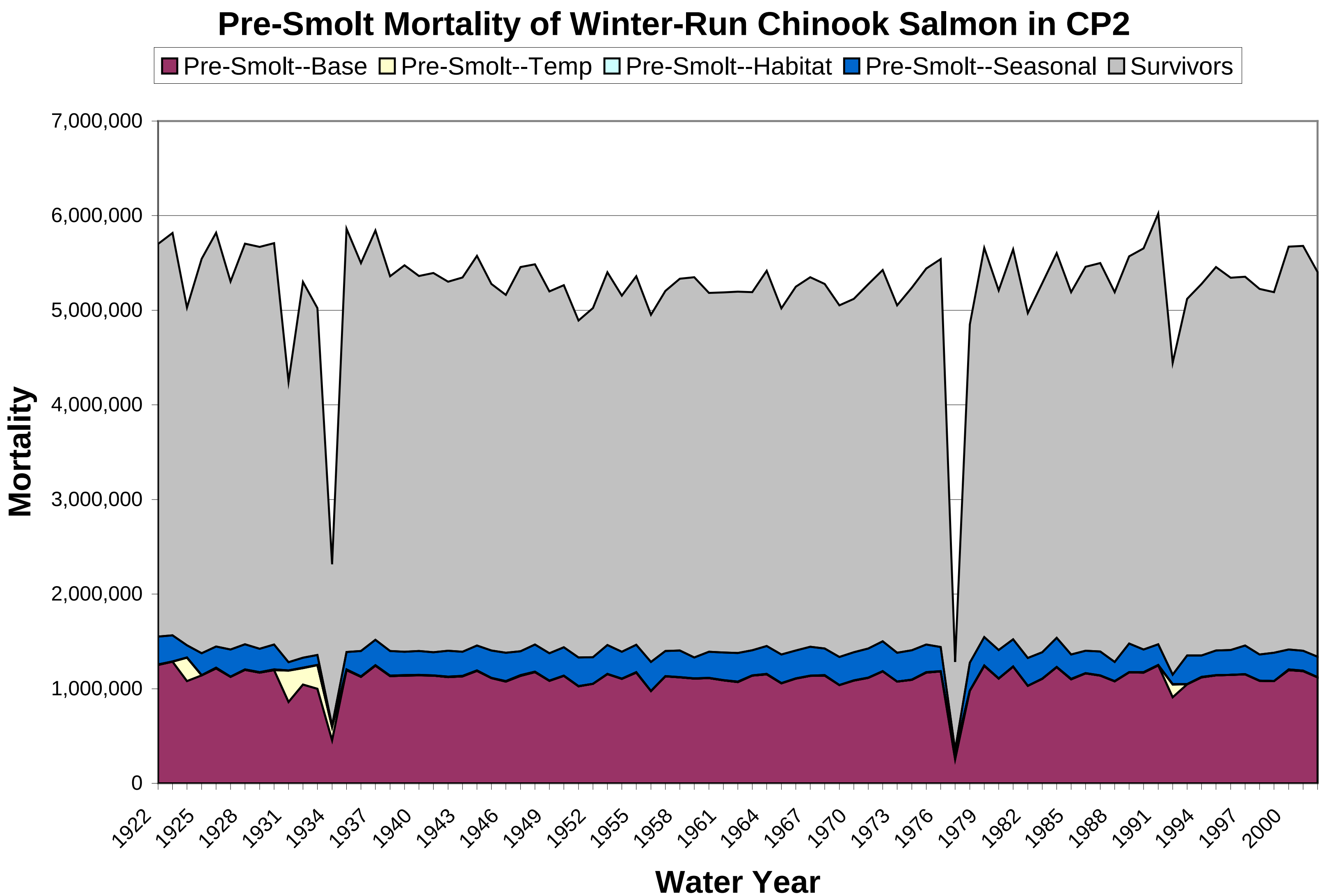

Figure B-10C. Source of mortality of winter-run Chinook salmon pre-smolts in CP2 based on the 1999-2006 population average.

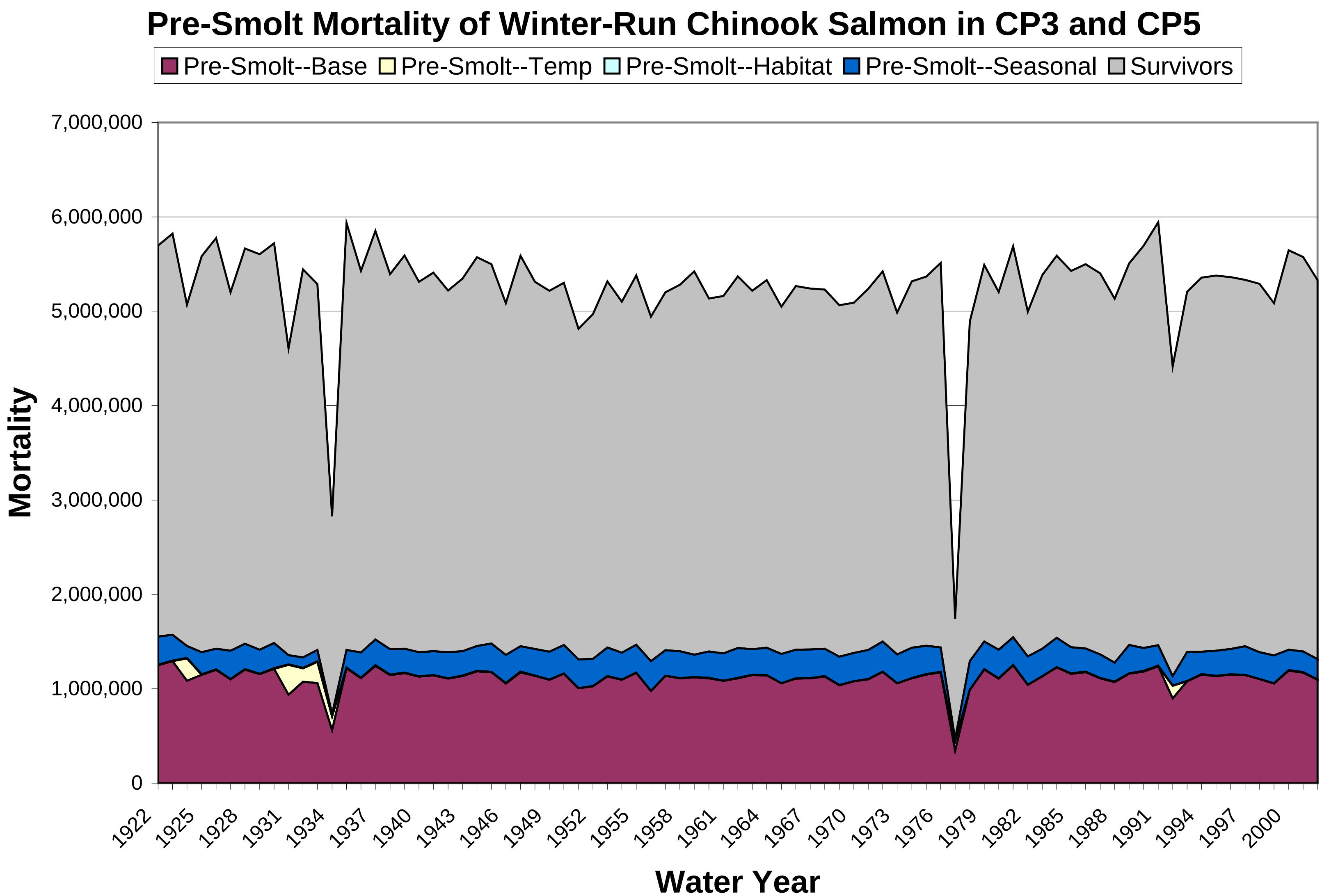

Figure B-10D. Source of mortality of winter-run Chinook salmon pre-smolts in CP3 and CP5 based on the 1999-2006 population average.

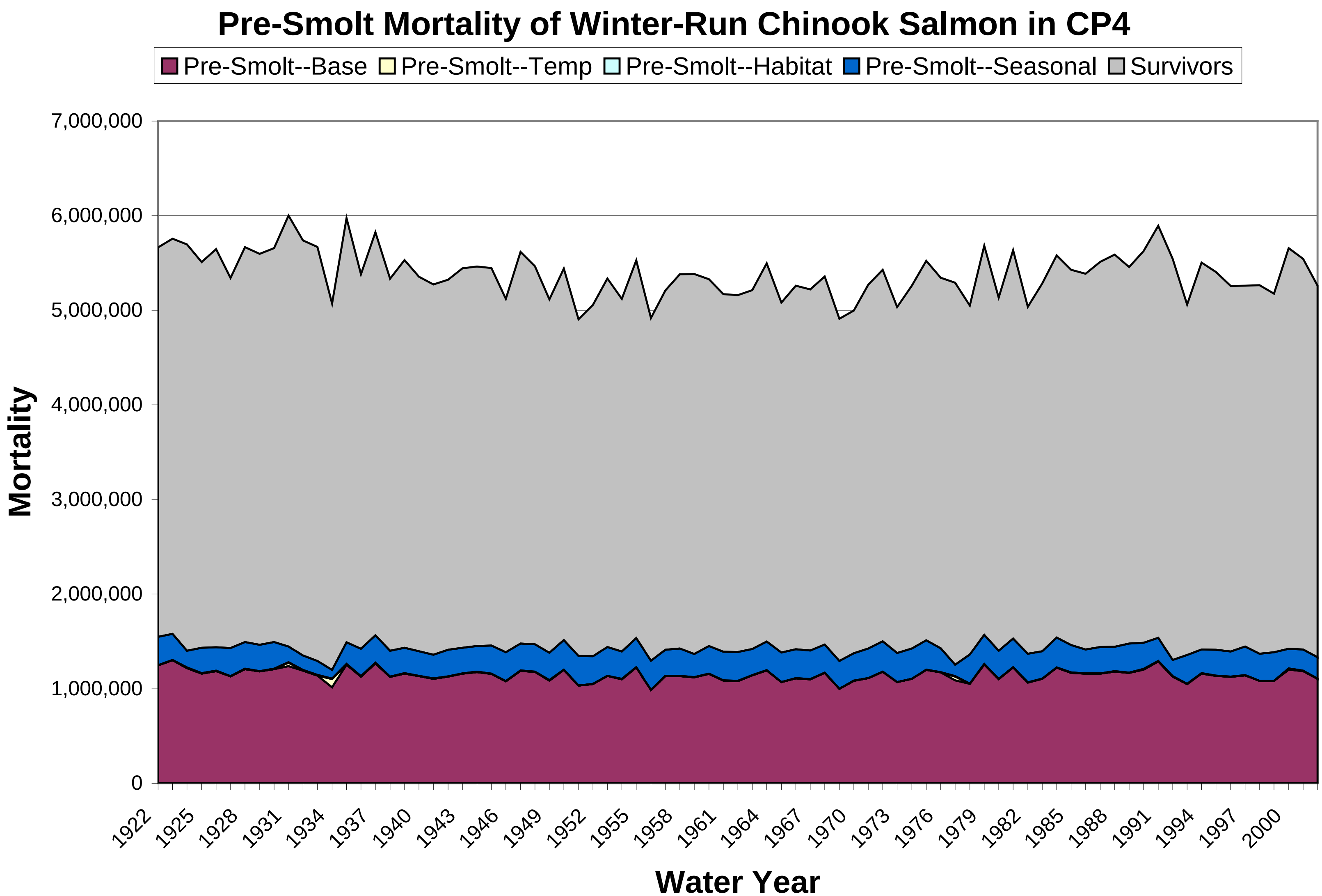

Figure B-10E. Source of mortality of winter-run Chinook salmon pre-smolts in CP4 based on the 1999-2006 population average.

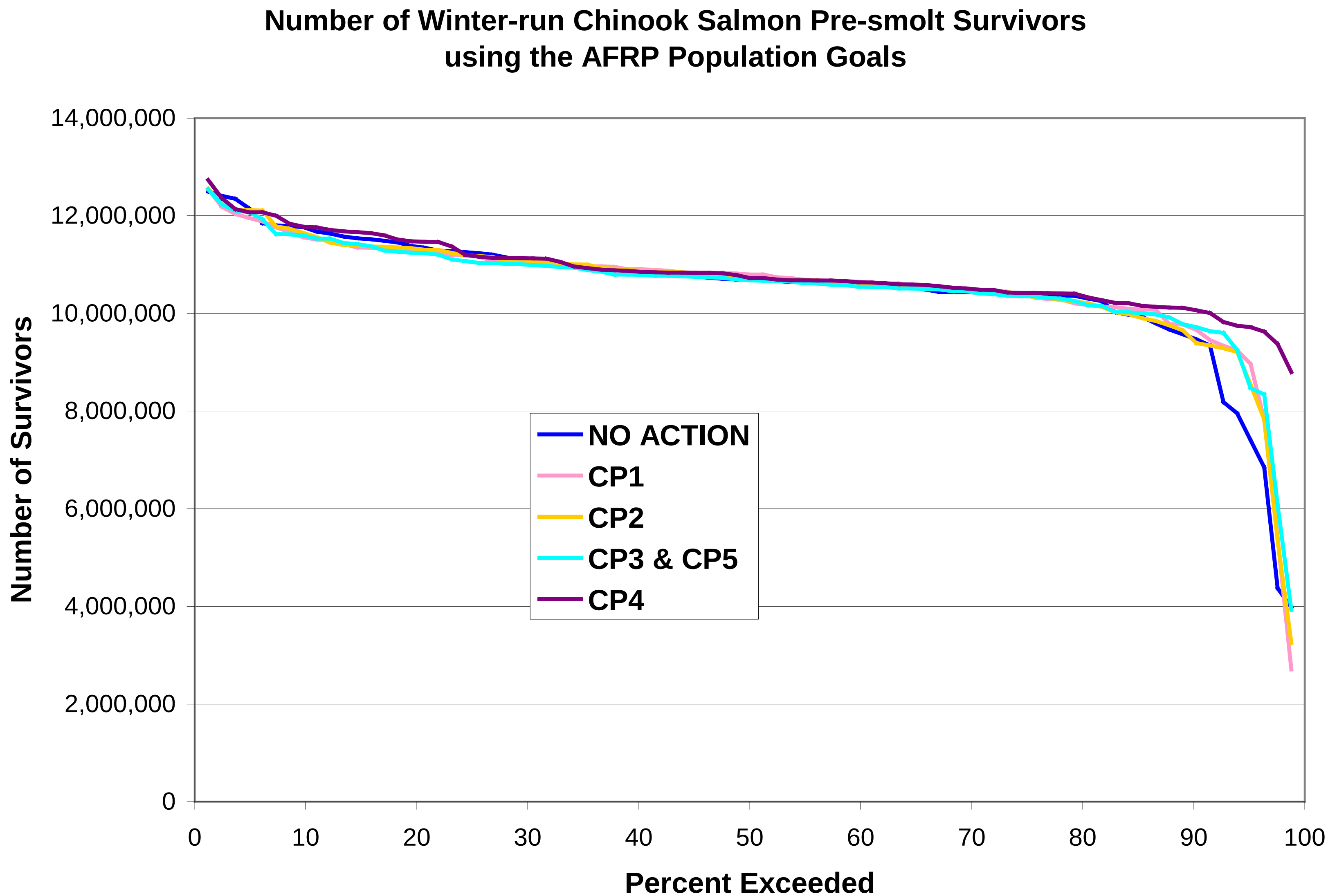

Figure B-11A. Frequency distribution of the number of winter-run Chinook salmon pre-smolt survivors during the 1921-2003 simulation period based on the AFRP population goals.

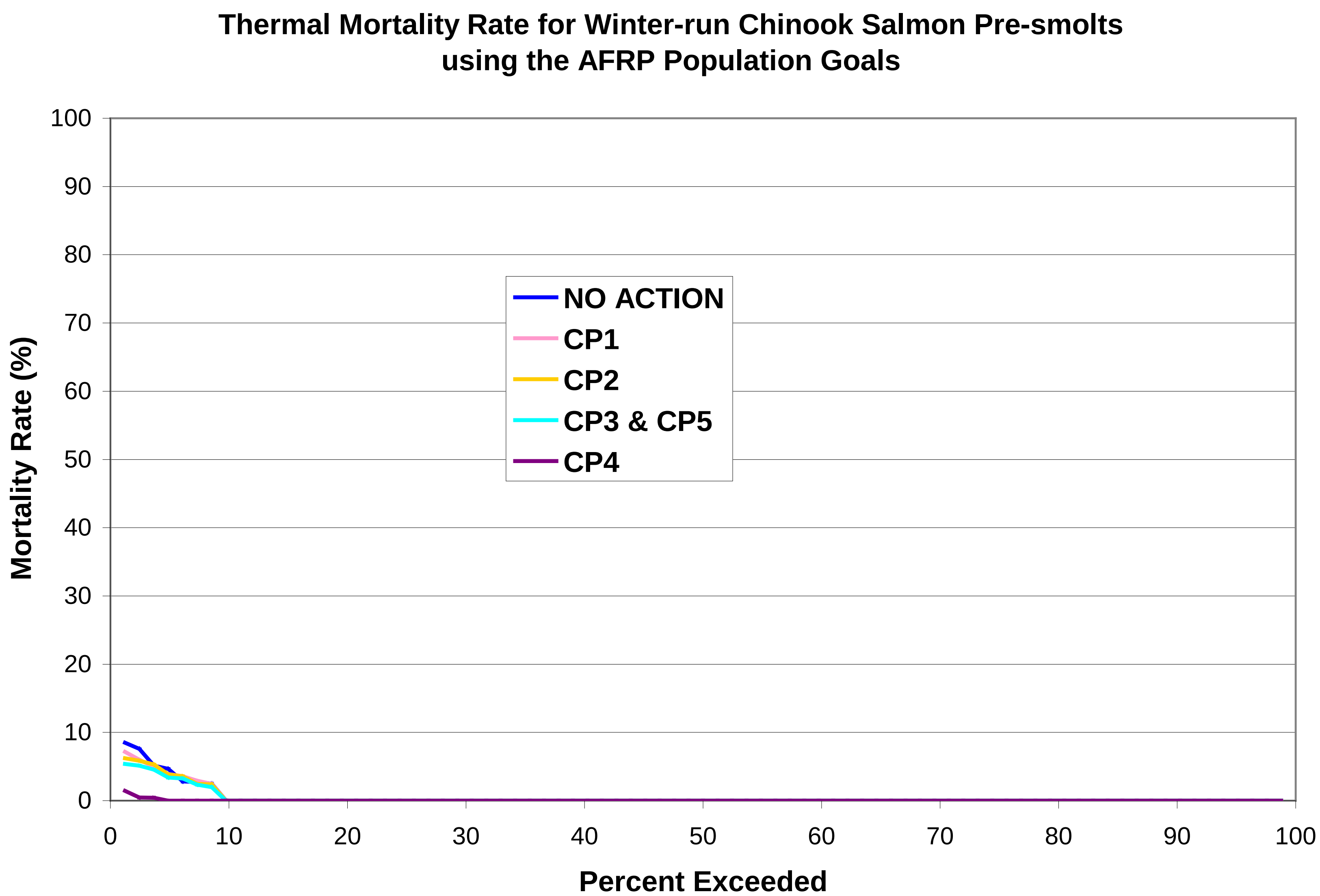

Figure B-11B. Frequency distribution of the thermal mortality rate of winter-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the AFRP population goals.

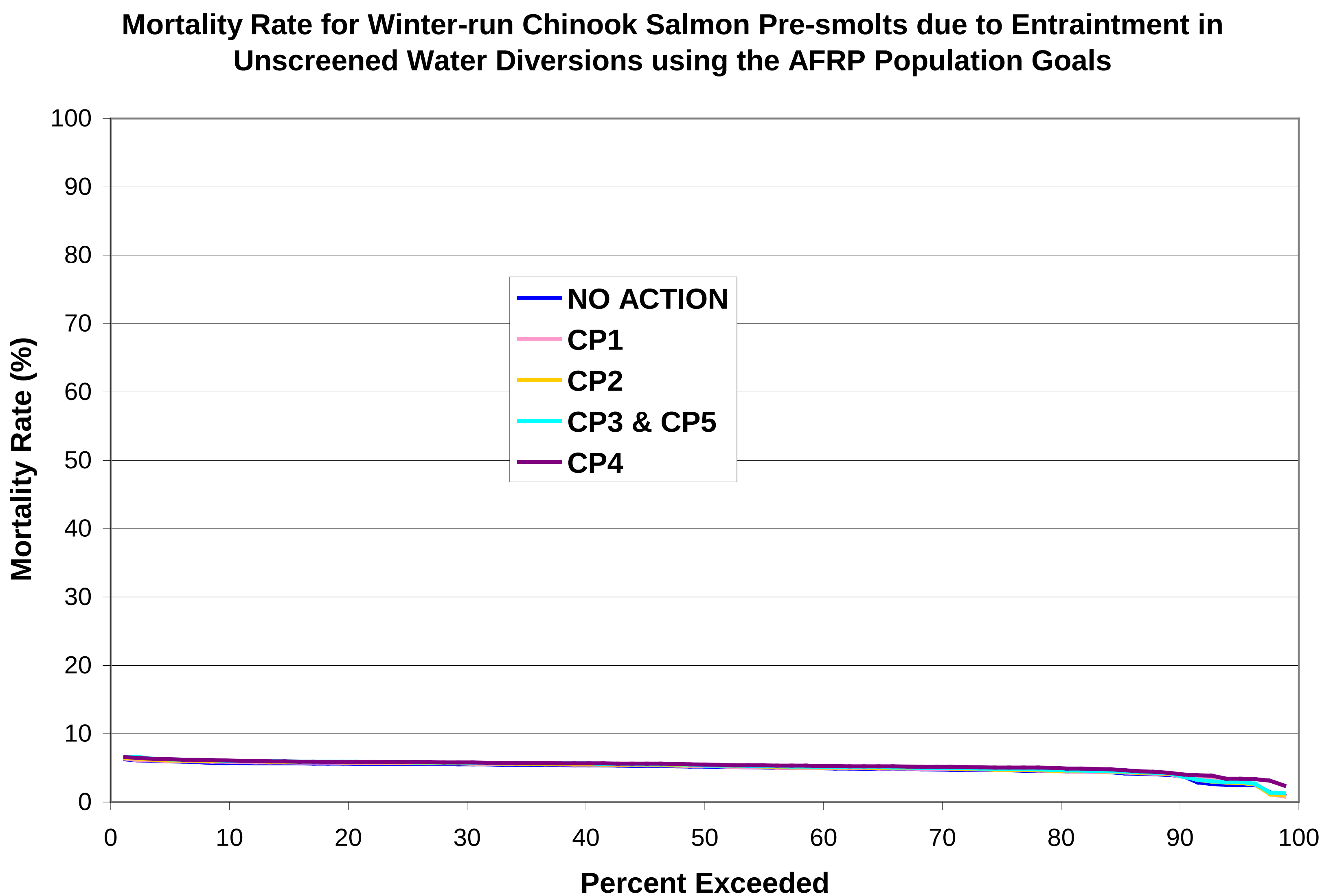

Figure B-11C. Frequency distribution of the mortality rate of winter-run Chinook salmon pre-smolts due to entrainment in unscreened water diversions during the 1921-2003 simulation period based on the AFRP population goals.

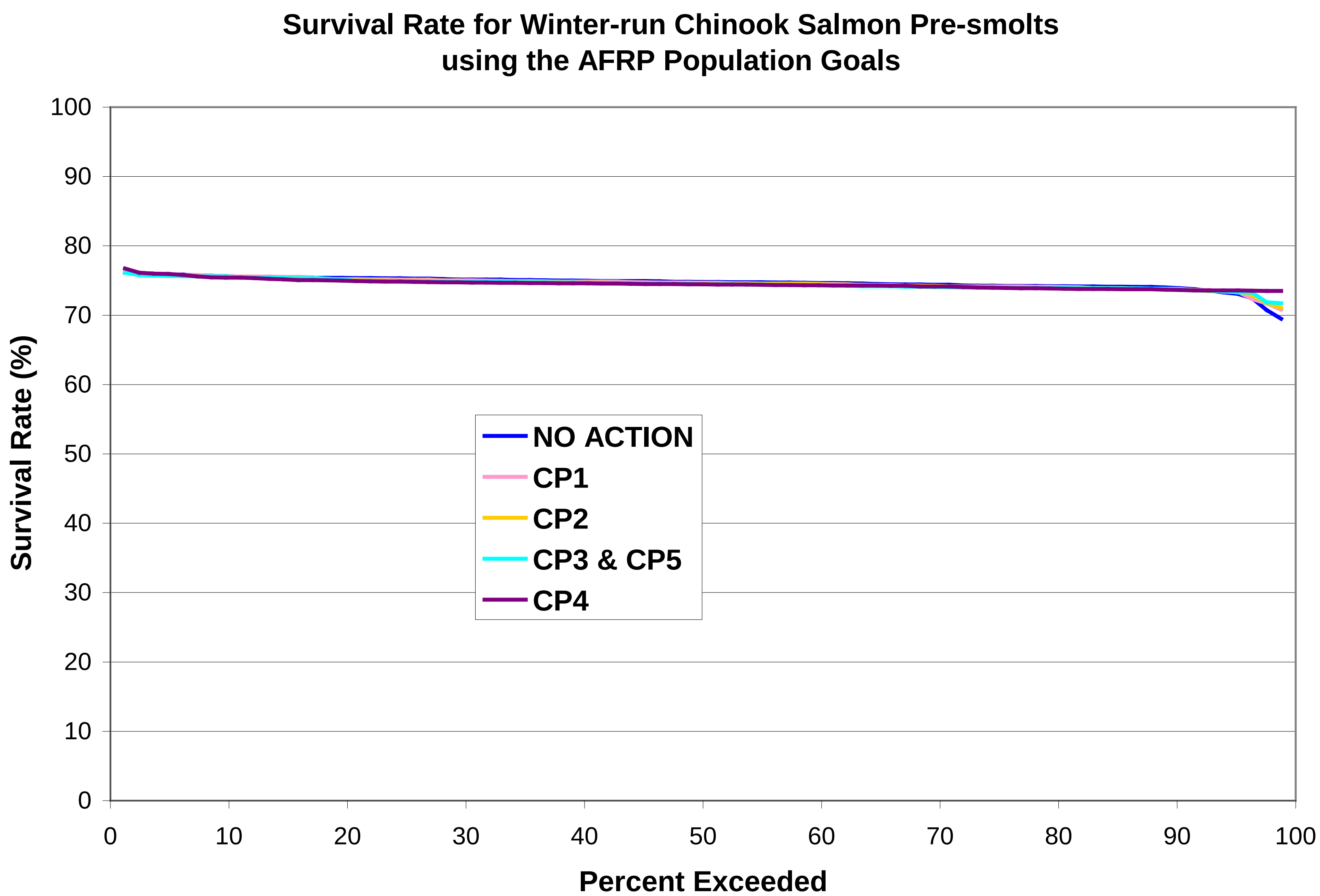

Figure B-11D. Frequency distribution of the survival rate of winter-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the AFRP population goals.

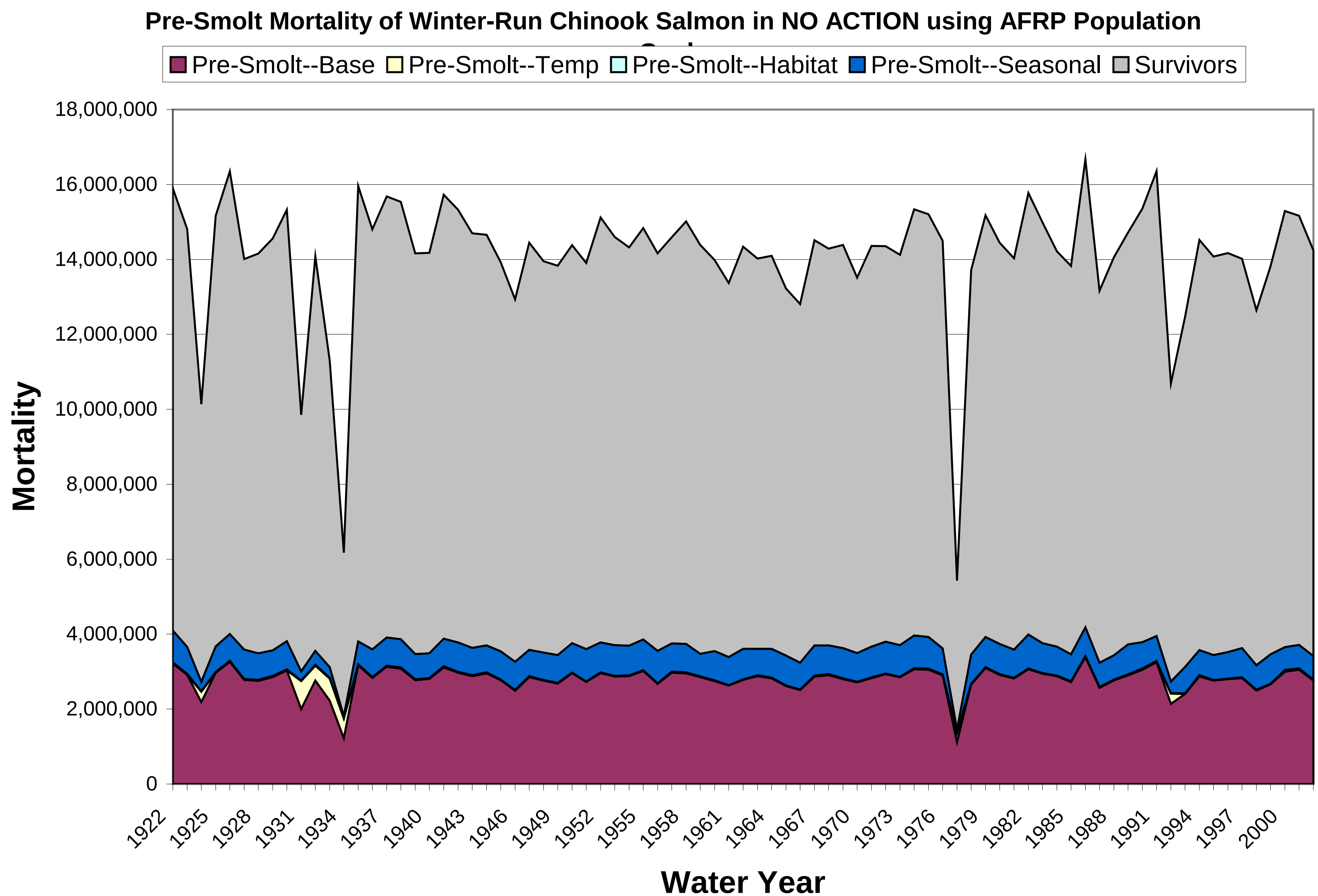

Figure B-12A. Source of mortality of winter-run Chinook salmon pre-smolts in NO ACTION based on AFRP population goals.

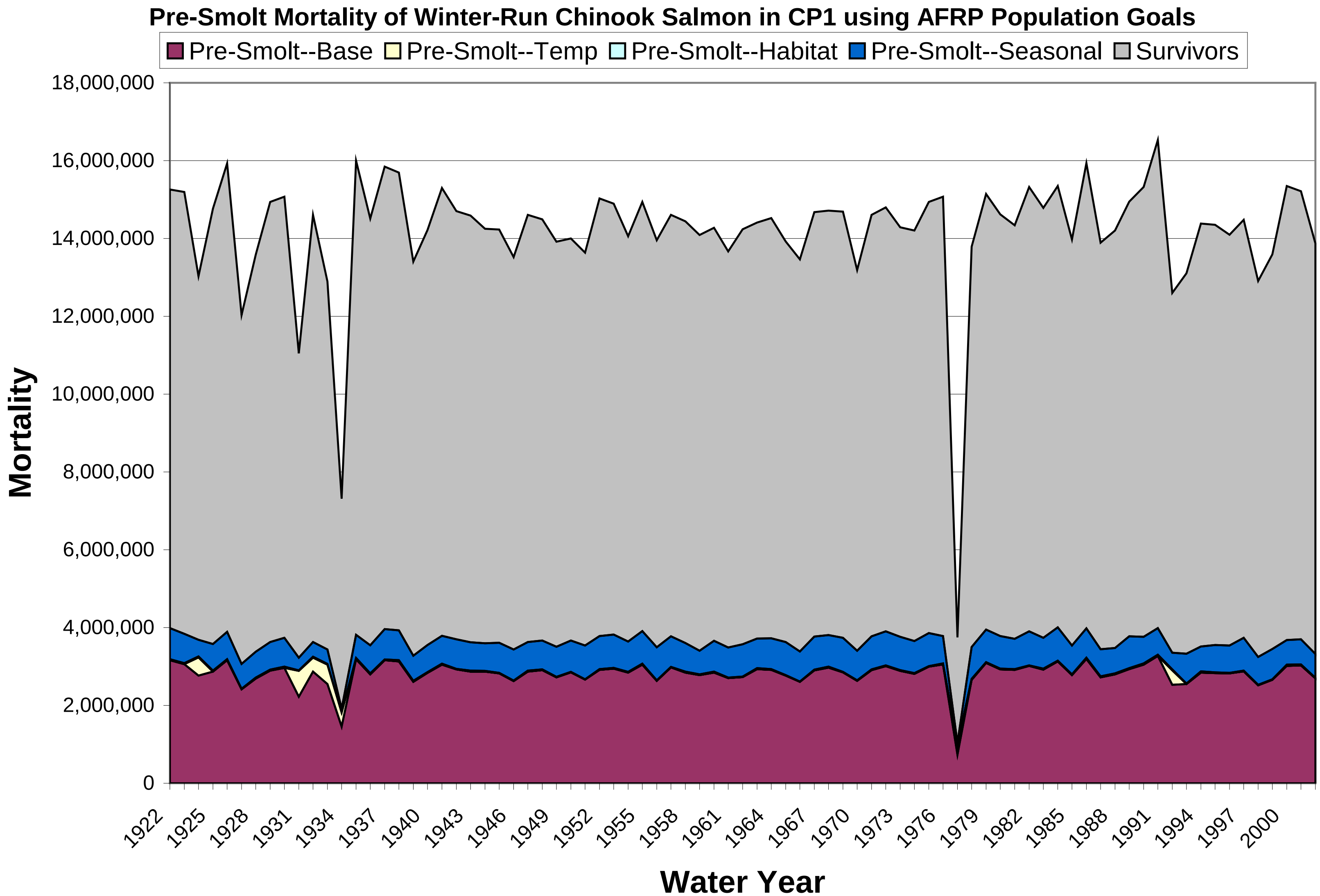

Figure B-12B. Source of mortality of winter-run Chinook salmon pre-smolts in CP1 based on AFRP population goals.

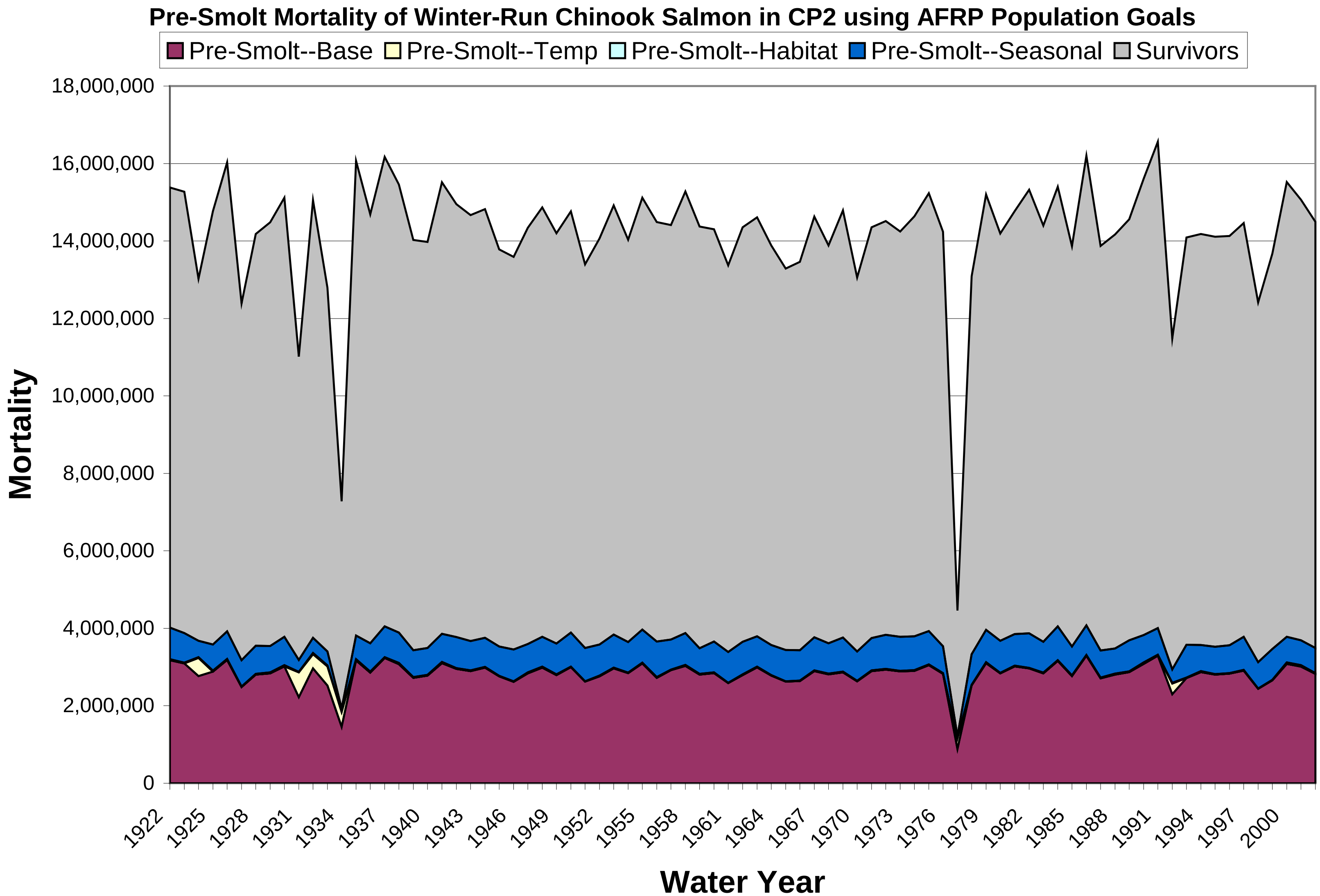

Figure B-12C. Source of mortality of winter-run Chinook salmon pre-smolts in CP2 based on AFRP population goals.

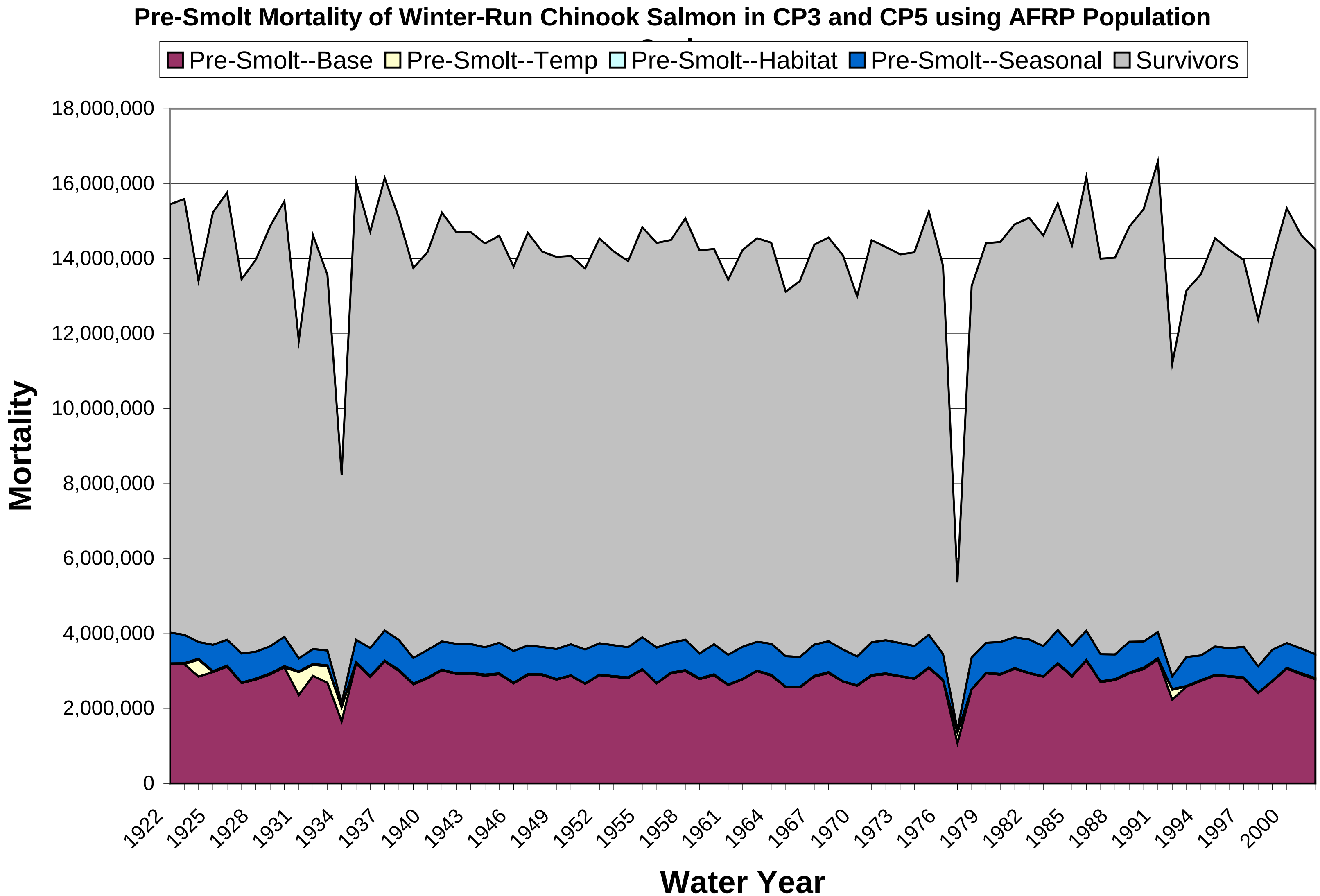

Figure B-12D. Source of mortality of winter-run Chinook salmon pre-smolts in CP3 and CP5 based on AFRP population goals.

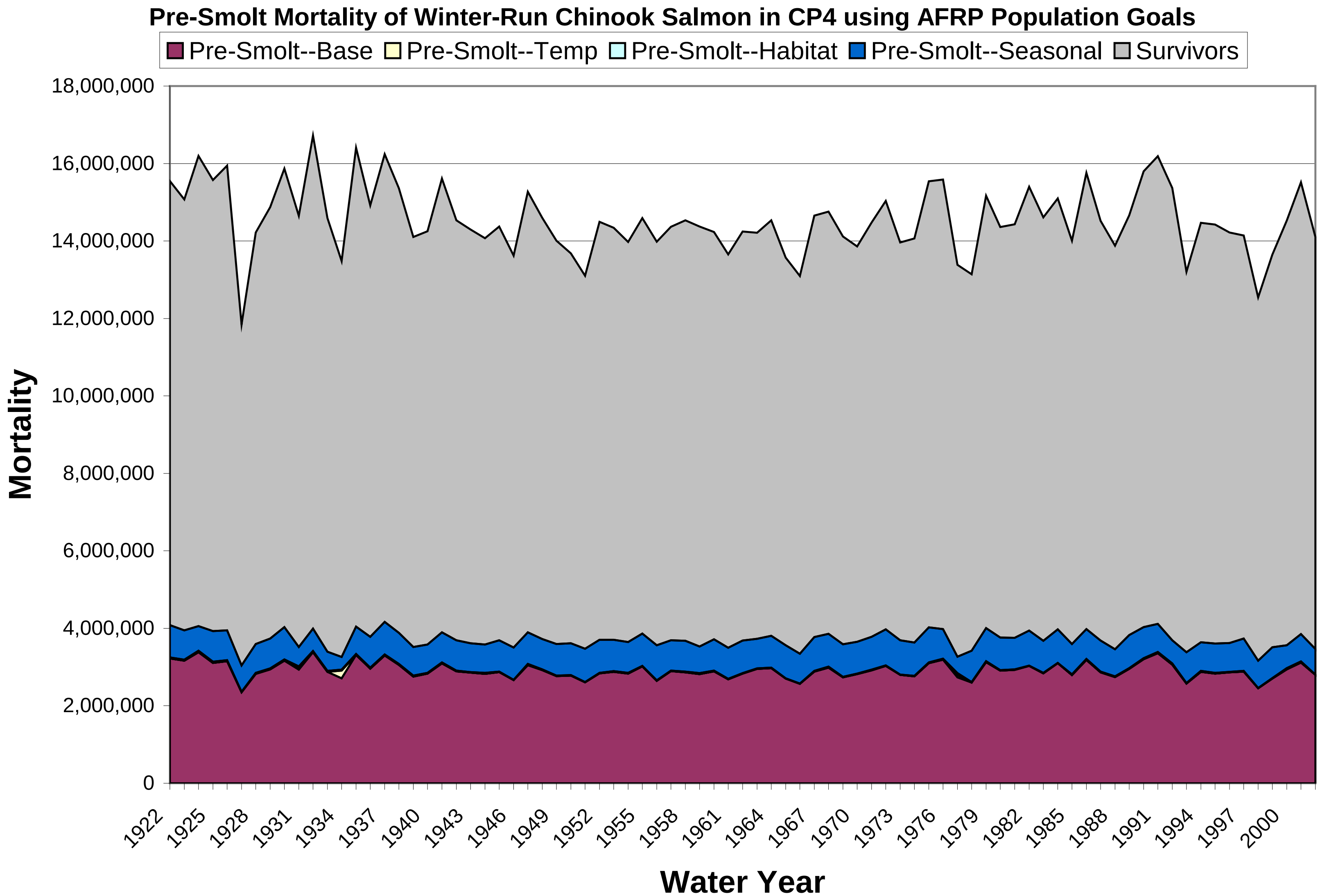

Figure B-12E. Source of mortality of winter-run Chinook salmon pre-smolts in CP4 based on AFRP population goals.

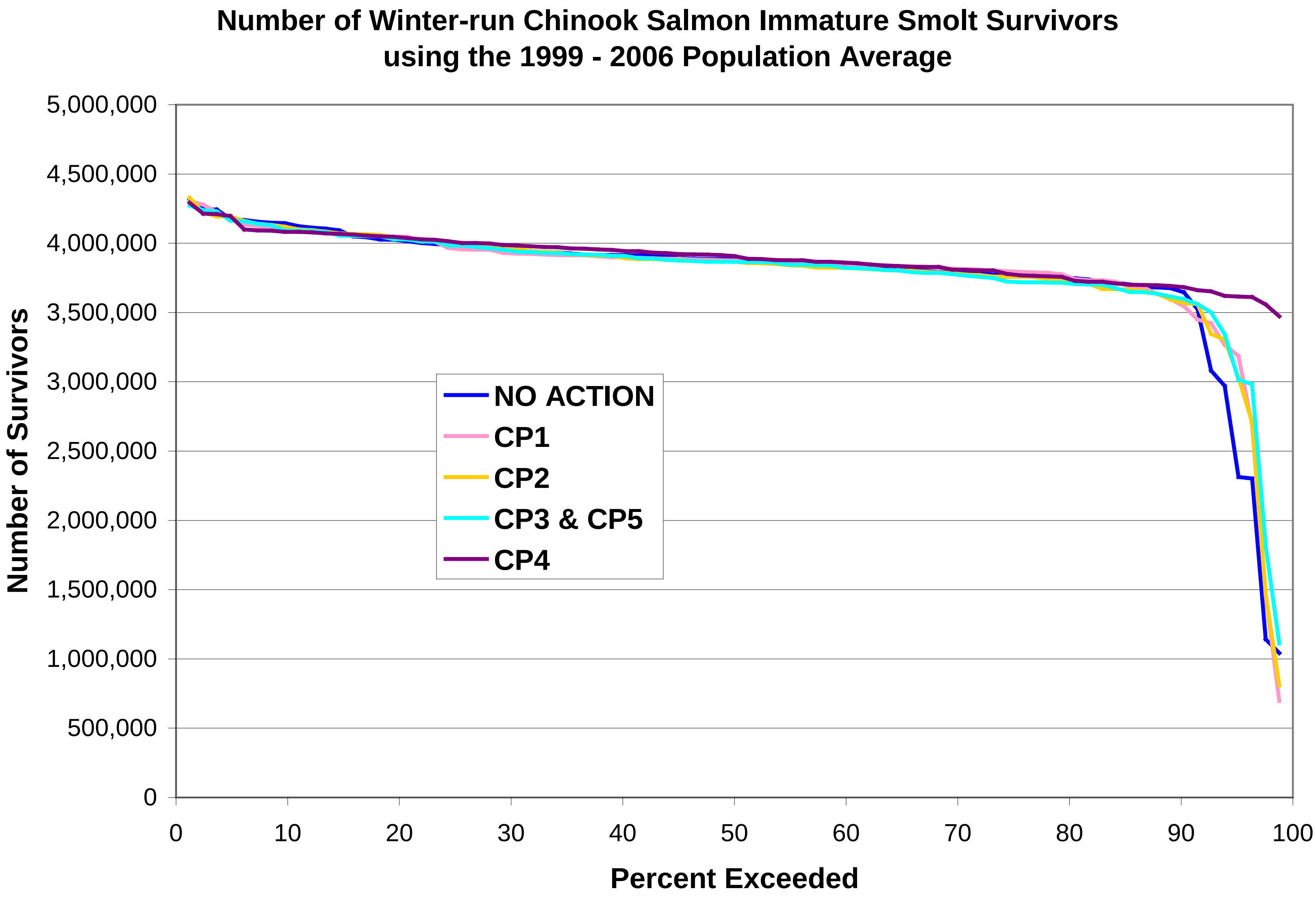

Figure B-13A. Frequency distribution of the number of winter-run Chinook salmon immature smolt survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

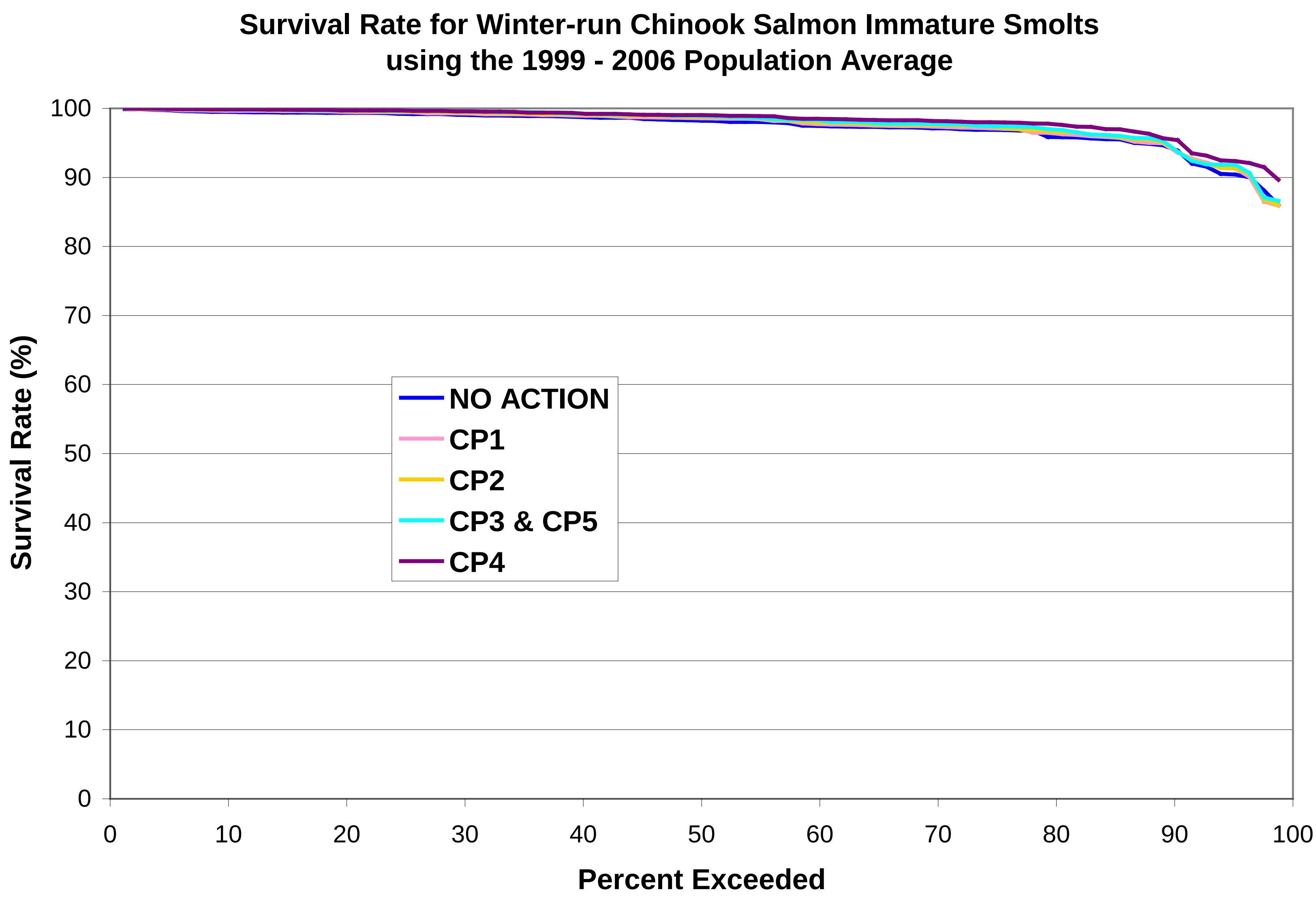

Figure B-13B. Frequency distribution of the survival rate of winter-run Chinook salmon immature smolts during the 1921-2003 simulation period based on the 1999-2006 population average.

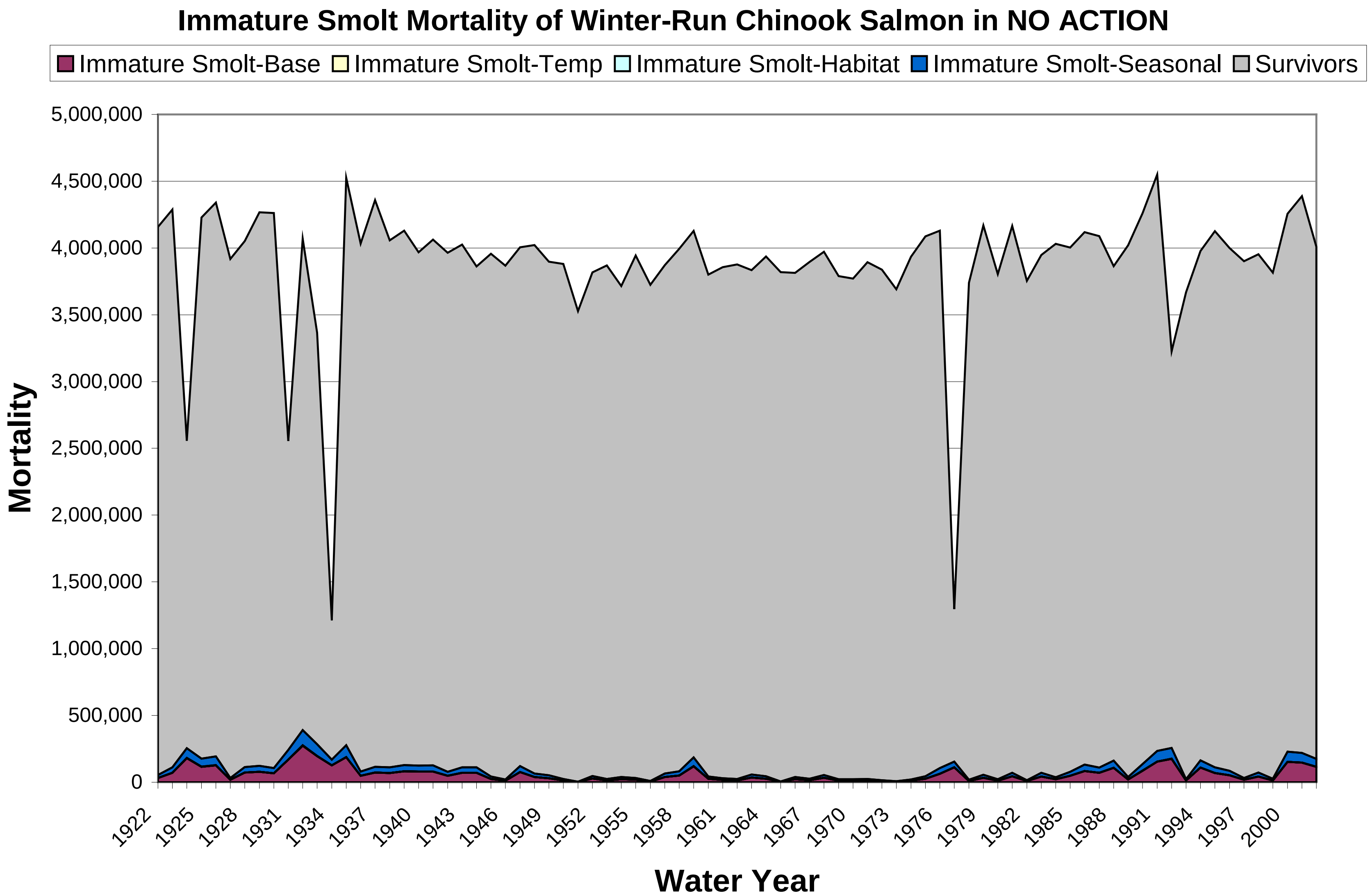

Figure B-14A. Source of mortality of winter-run Chinook salmon immature smolts in NO ACTION based on the 1999 – 2006 population average.

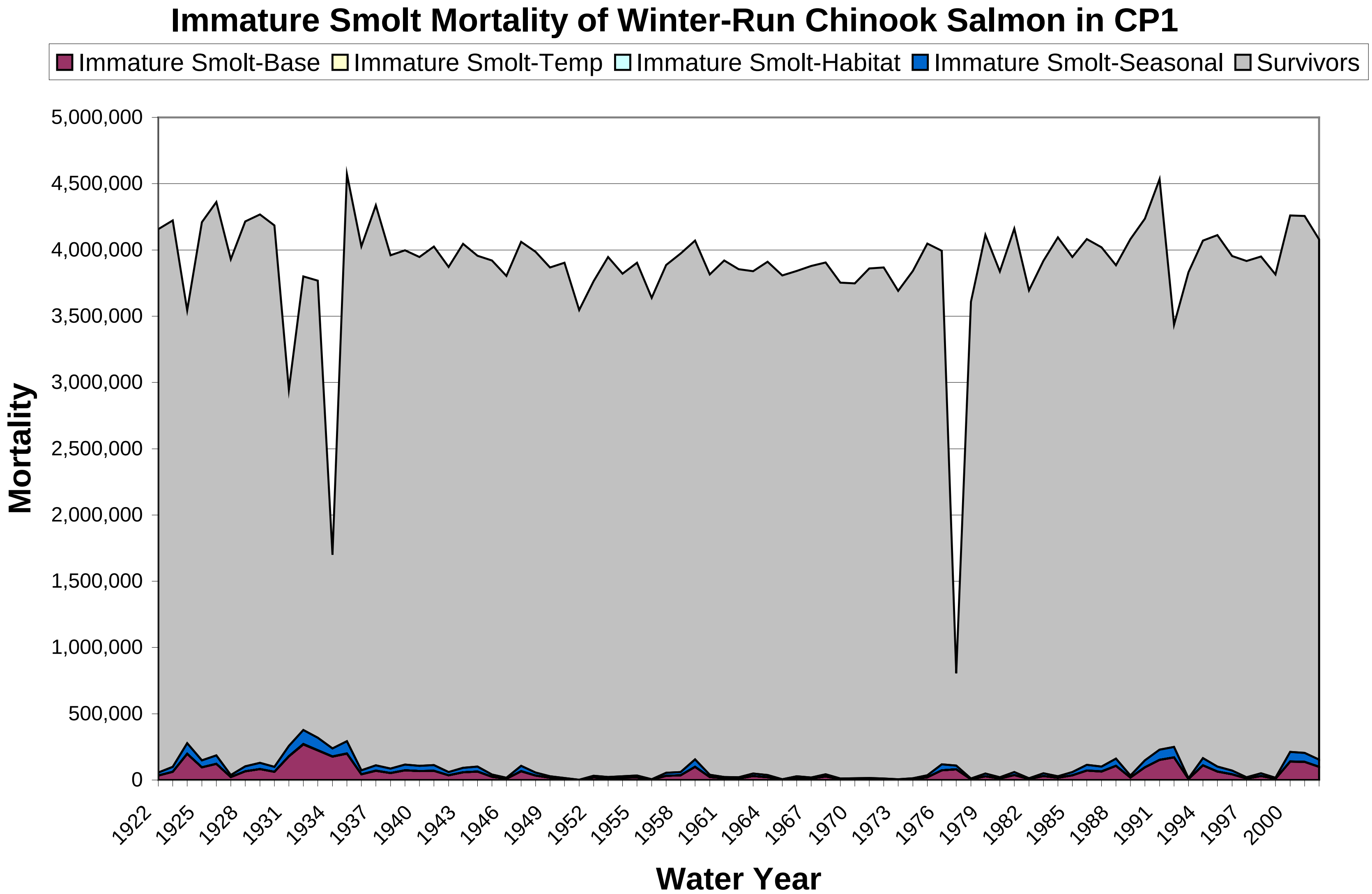

Figure B-14B. Source of mortality of winter-run Chinook salmon immature smolts in CP1 based on the 1999 – 2006 population average.

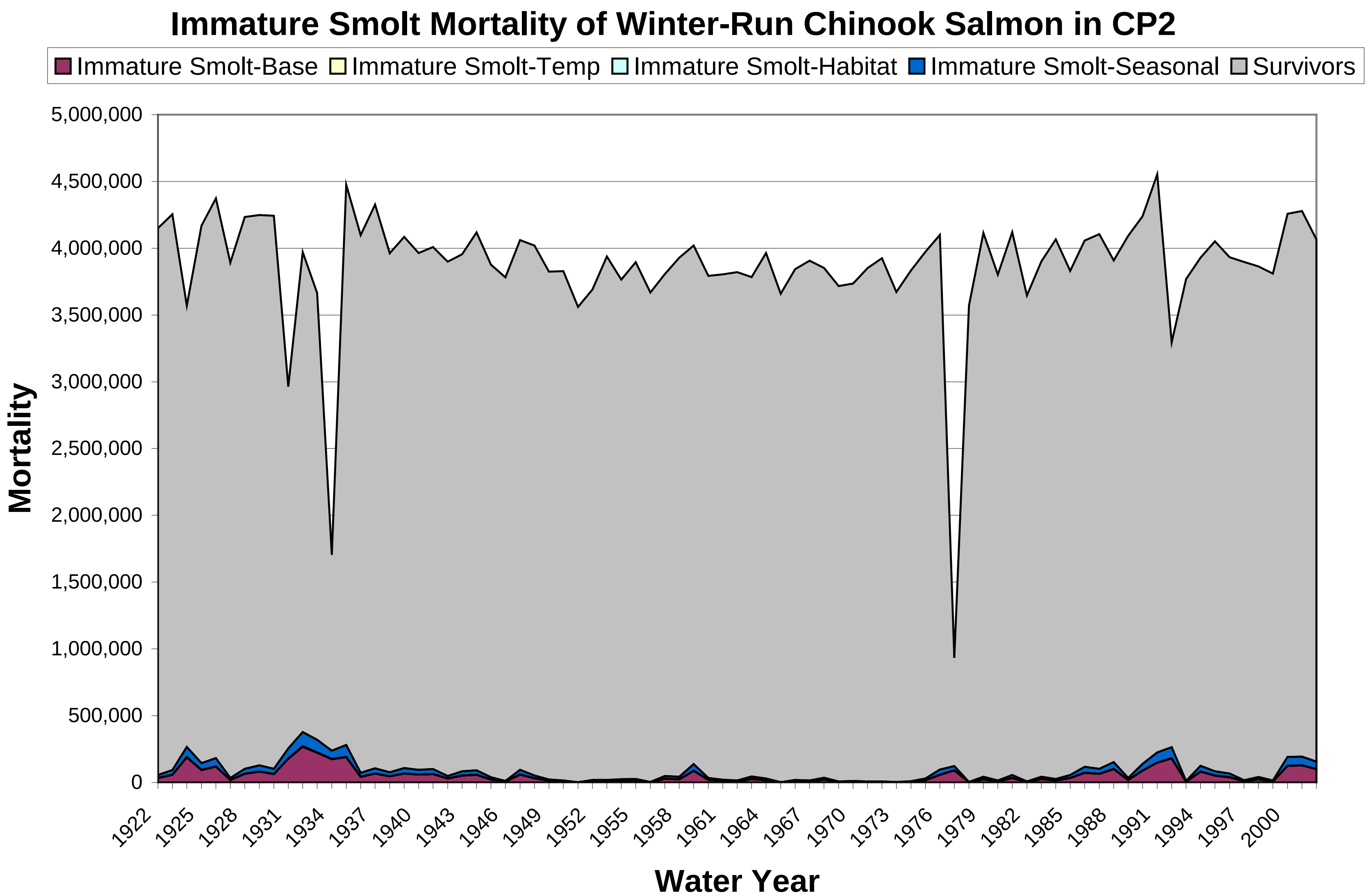

Figure B-14C. Source of mortality of winter-run Chinook salmon immature smolts in CP2 based on the 1999 – 2006 population average.

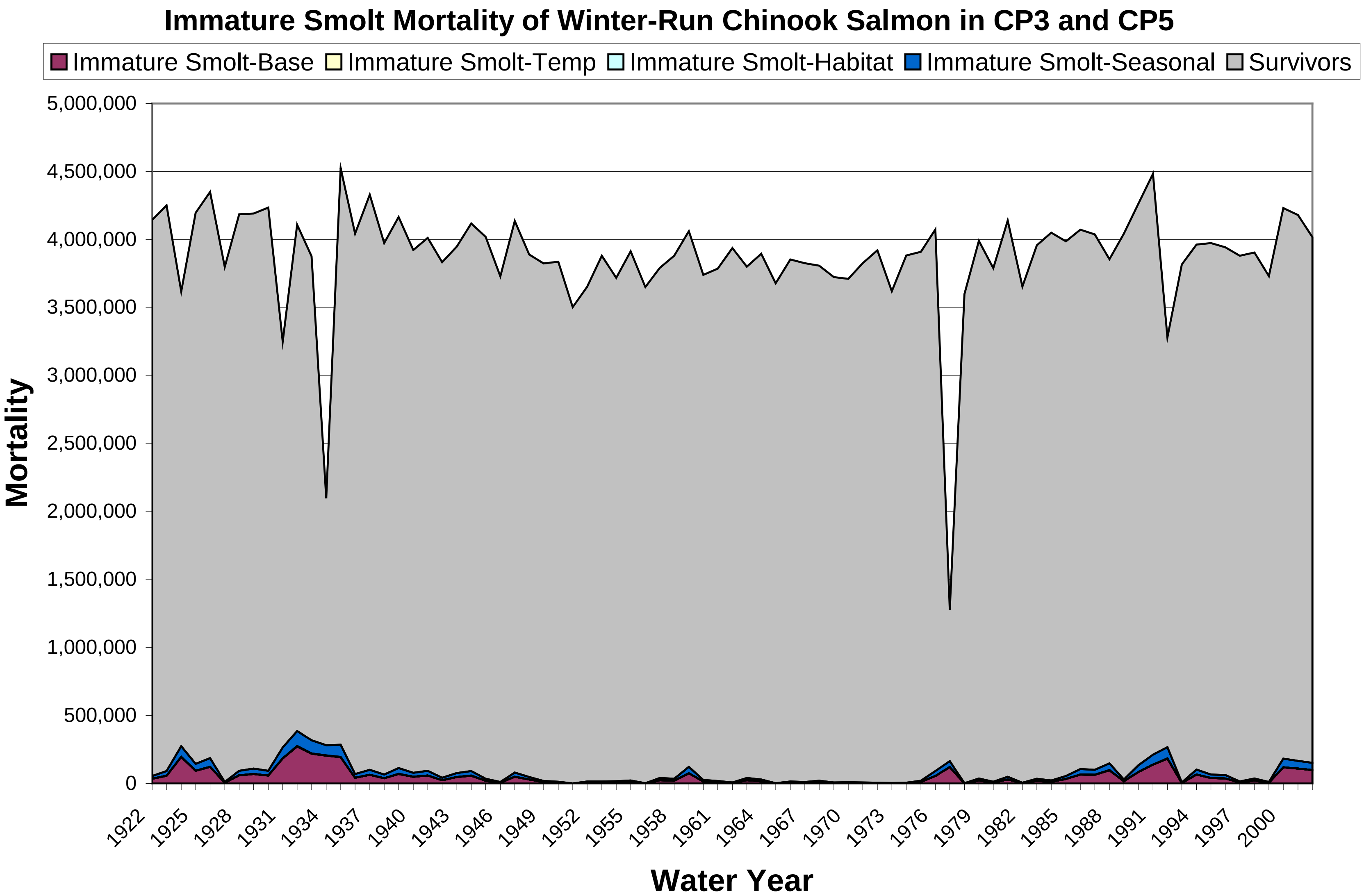

Figure B-14D. Source of mortality of winter-run Chinook salmon immature smolts in CP3 and CP5 based on the 1999 – 2006 population average.

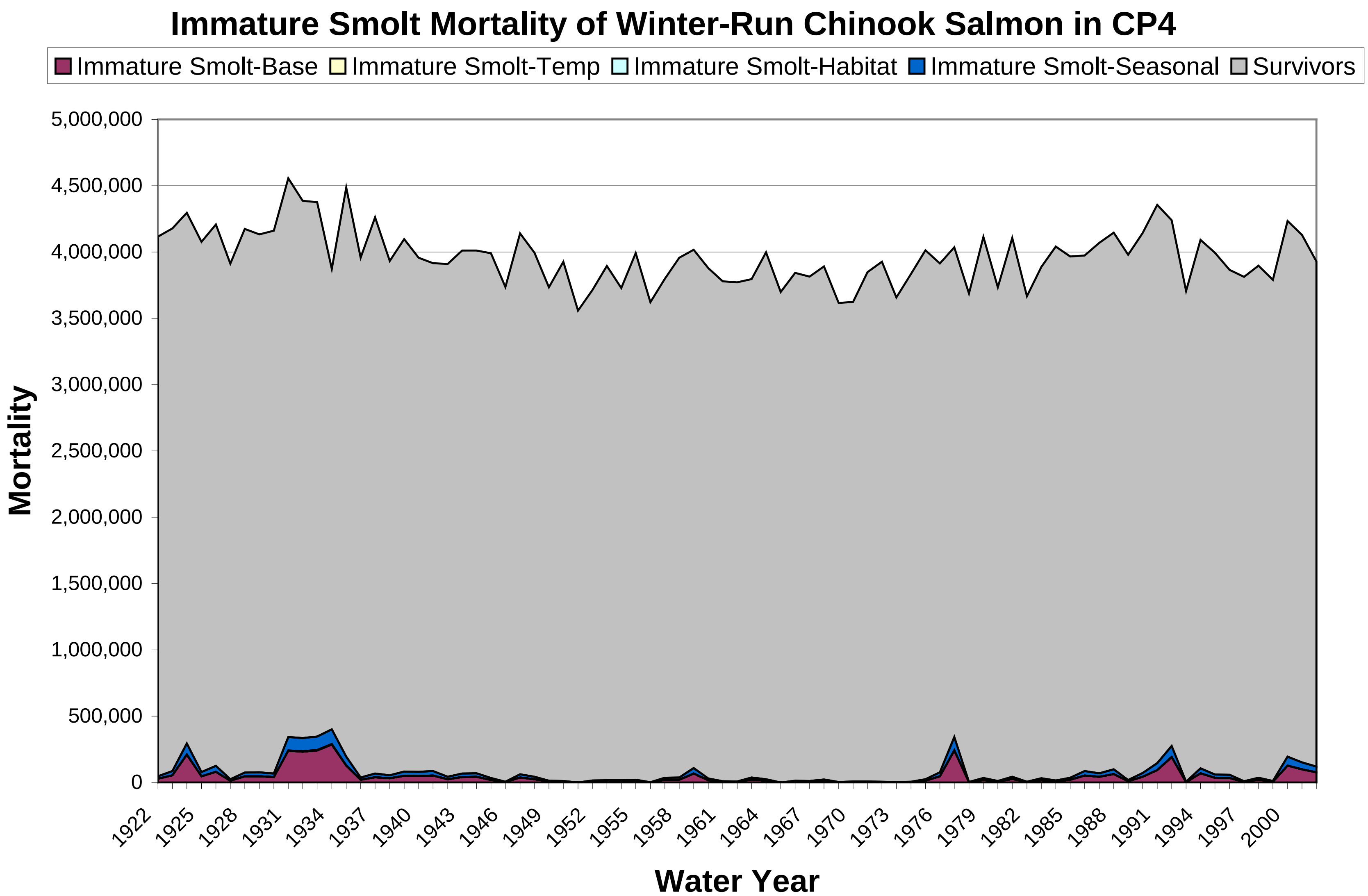

Figure B-14E. Source of mortality of winter-run Chinook salmon immature smolts in CP4 based on the 1999 – 2006 population average.

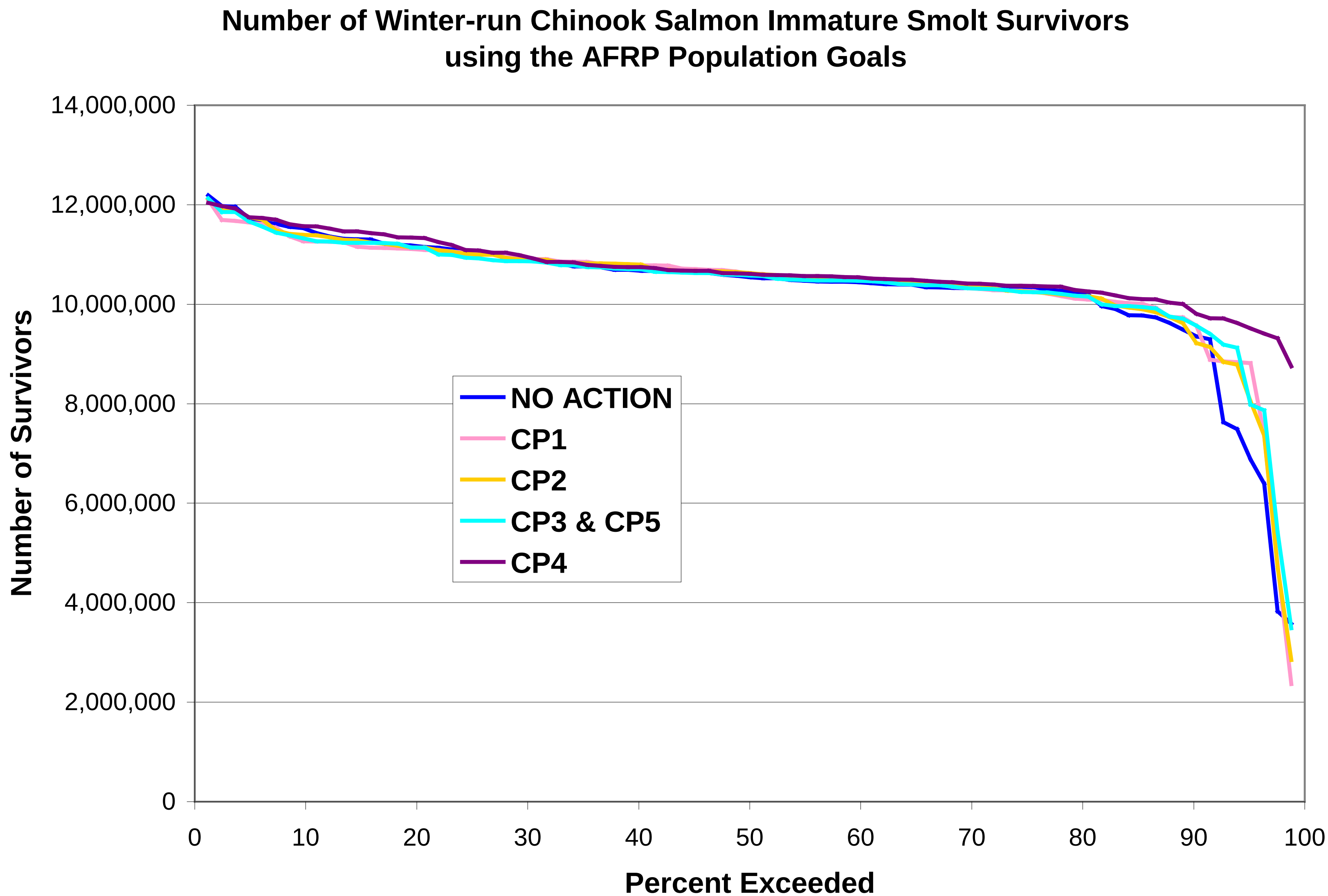

Figure B-15A. Frequency distribution of the number of winter-run Chinook salmon immature smolt survivors during the 1921-2003 simulation period based on the AFRP population goals.

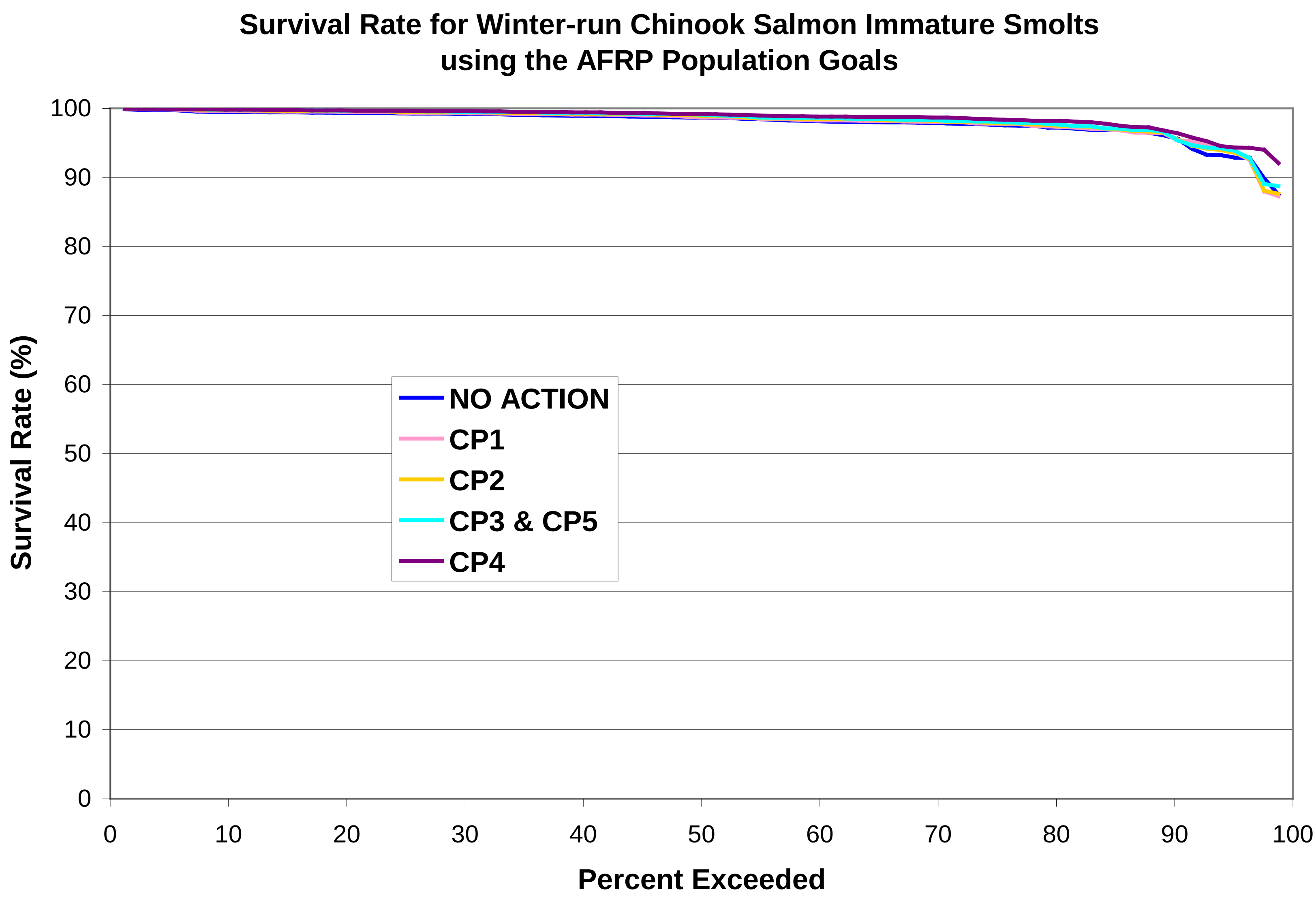

Figure B-15B. Frequency distribution of the survival rate of winter-run Chinook salmon immature smolts during the 1921-2003 simulation period based on the AFRP population goals.

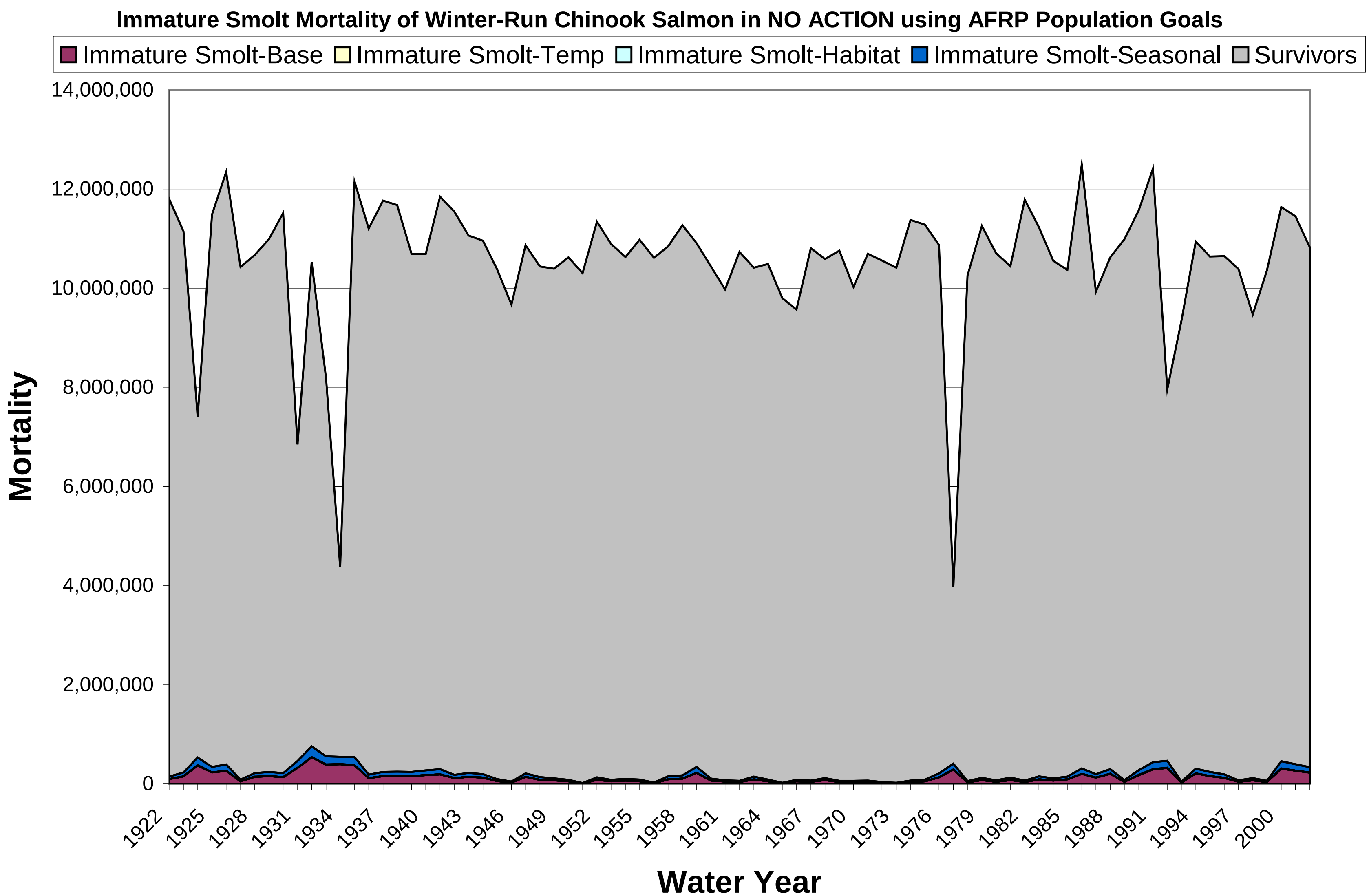

Figure B-16A. Source of mortality of winter-run Chinook salmon immature smolts in NO ACTION based on AFRP population goals.

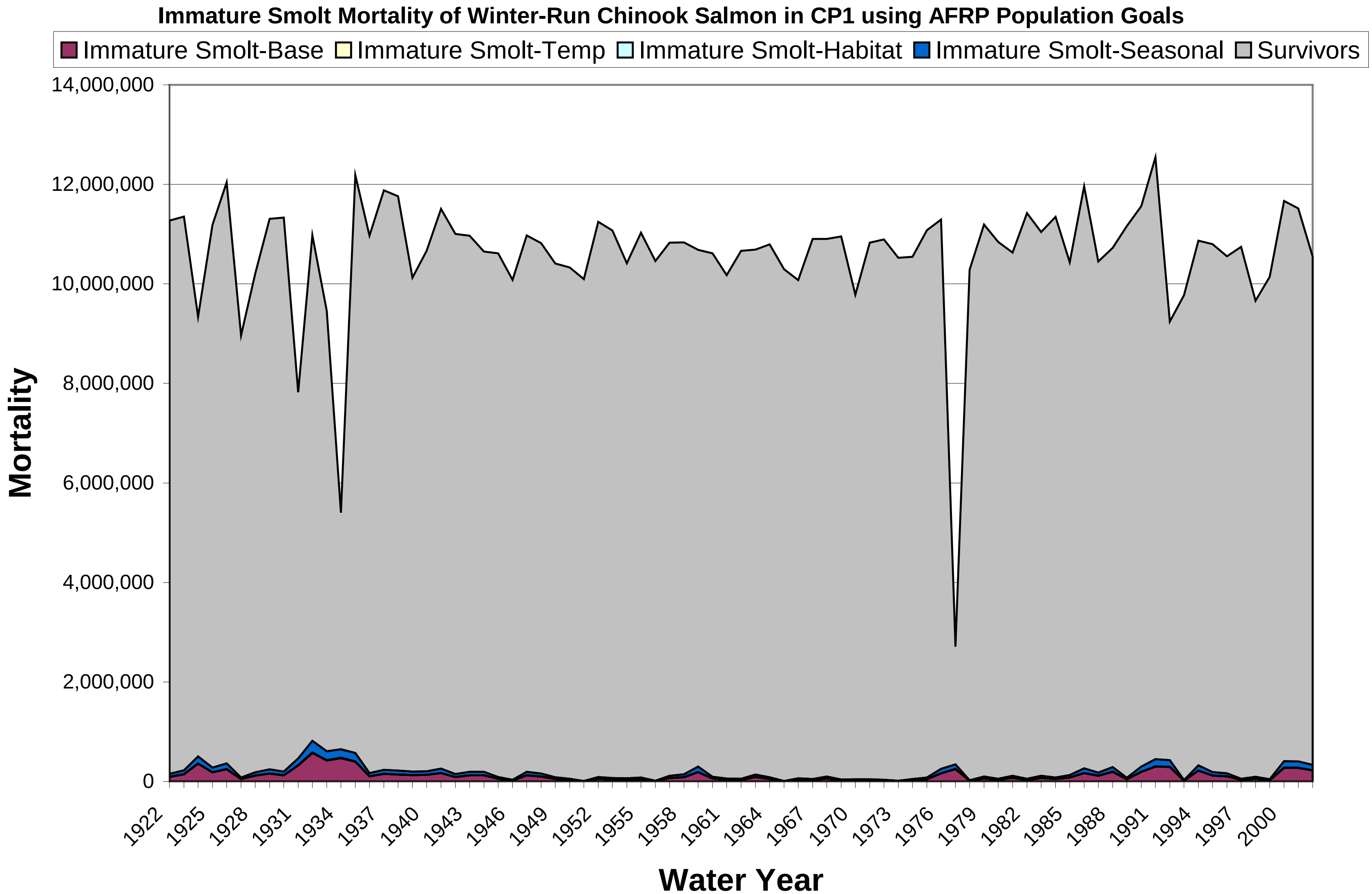

Figure B-16B. Source of mortality of winter-run Chinook salmon immature smolts in CP1 based on AFRP population goals.

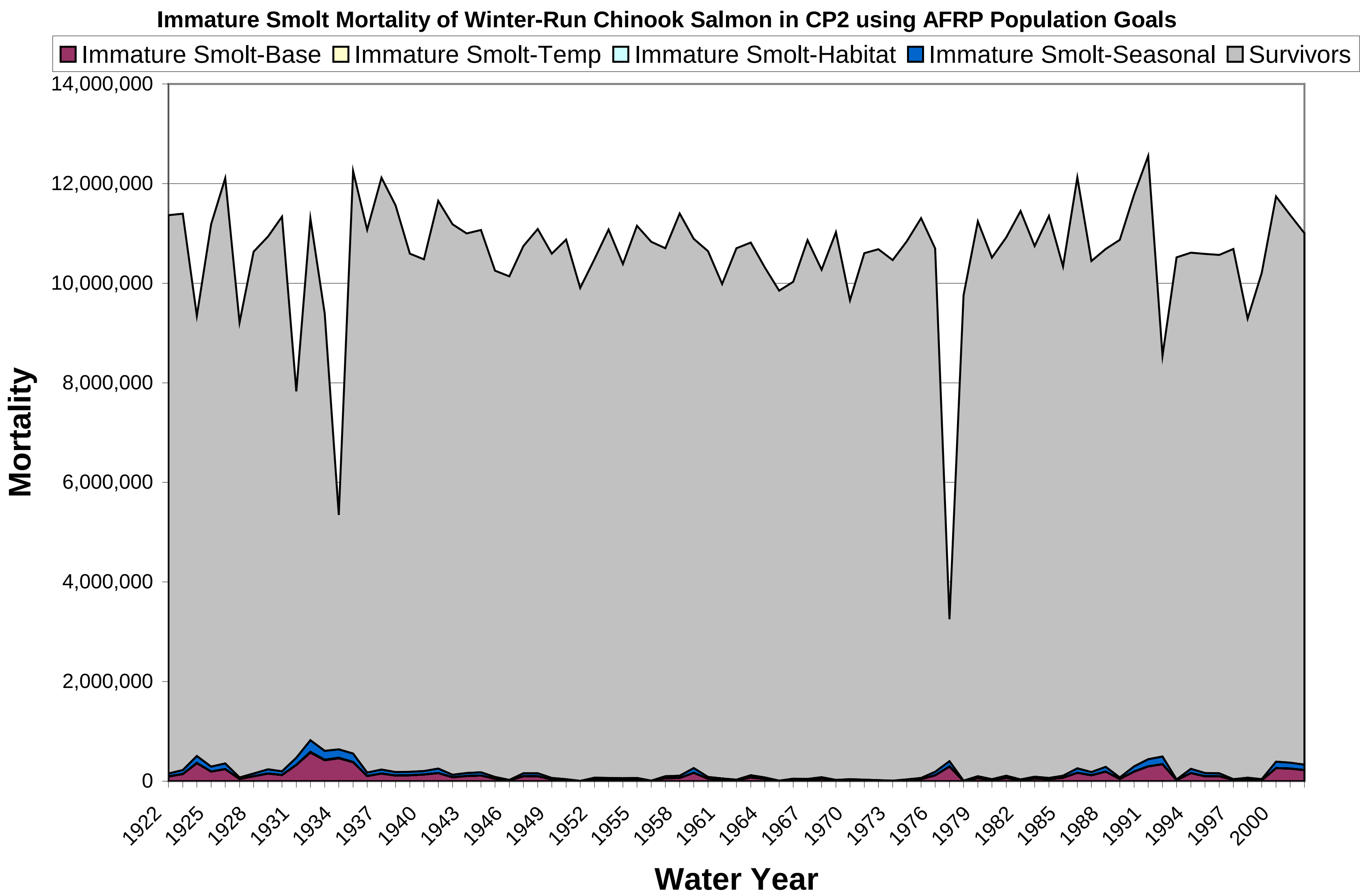

Figure B-16C. Source of mortality of winter-run Chinook salmon immature smolts in CP2 based on AFRP population goals.

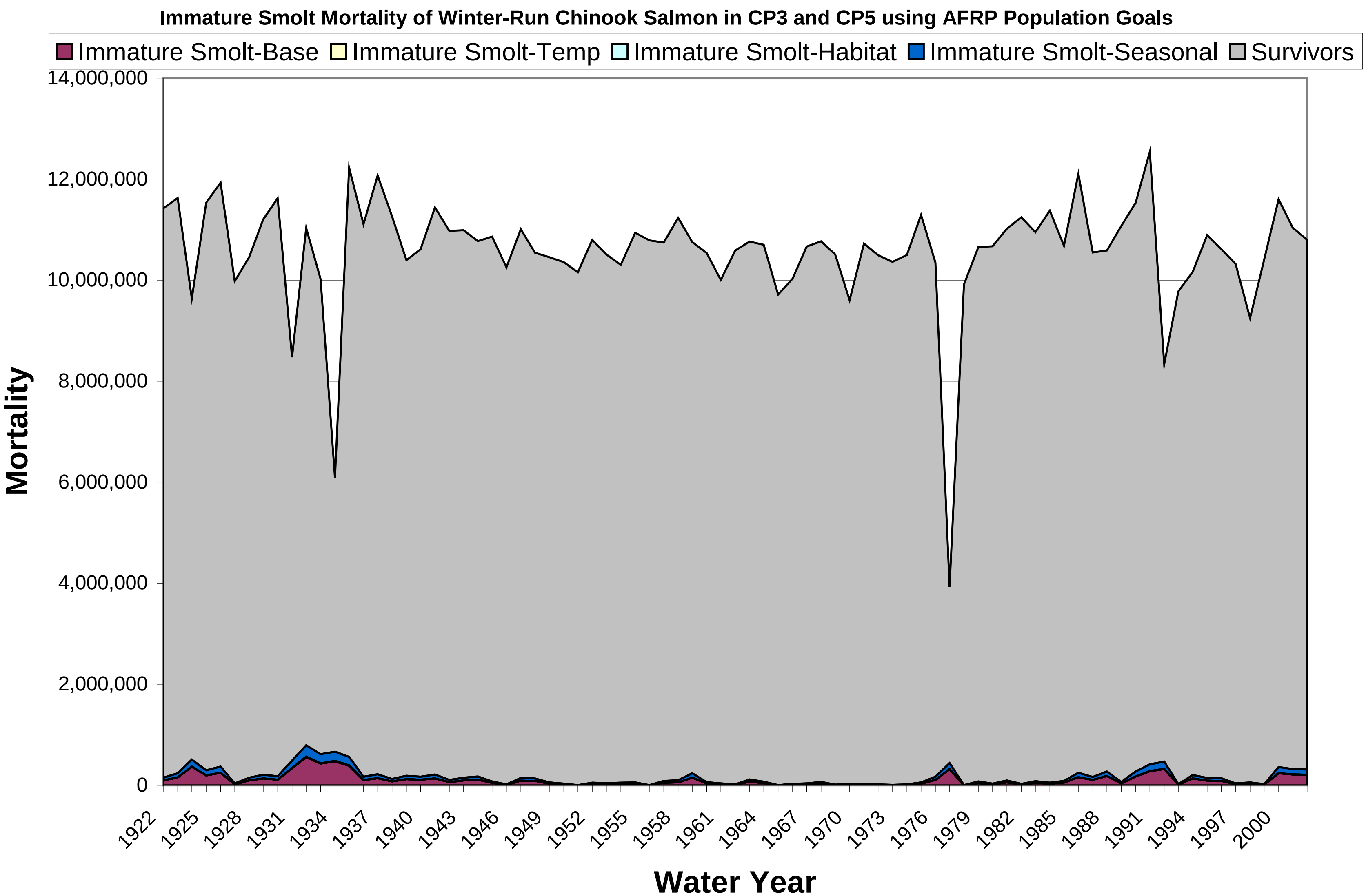

Figure B-16D. Source of mortality of winter-run Chinook salmon immature smolts in CP3 and CP5 based on AFRP population goals.

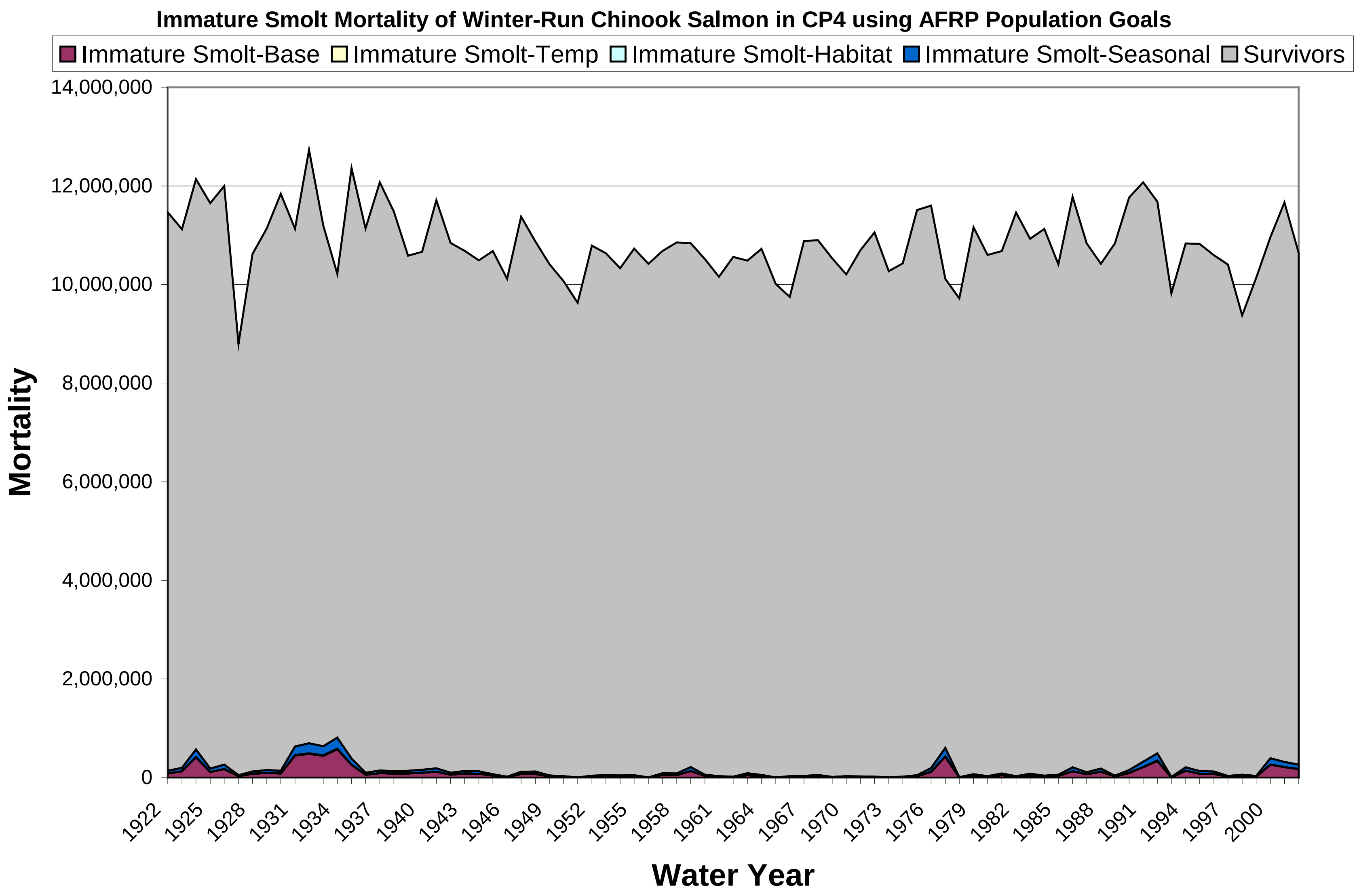

Figure B-16E. Source of mortality of winter-run Chinook salmon immature smolts in CP4 based on AFRP population goals.

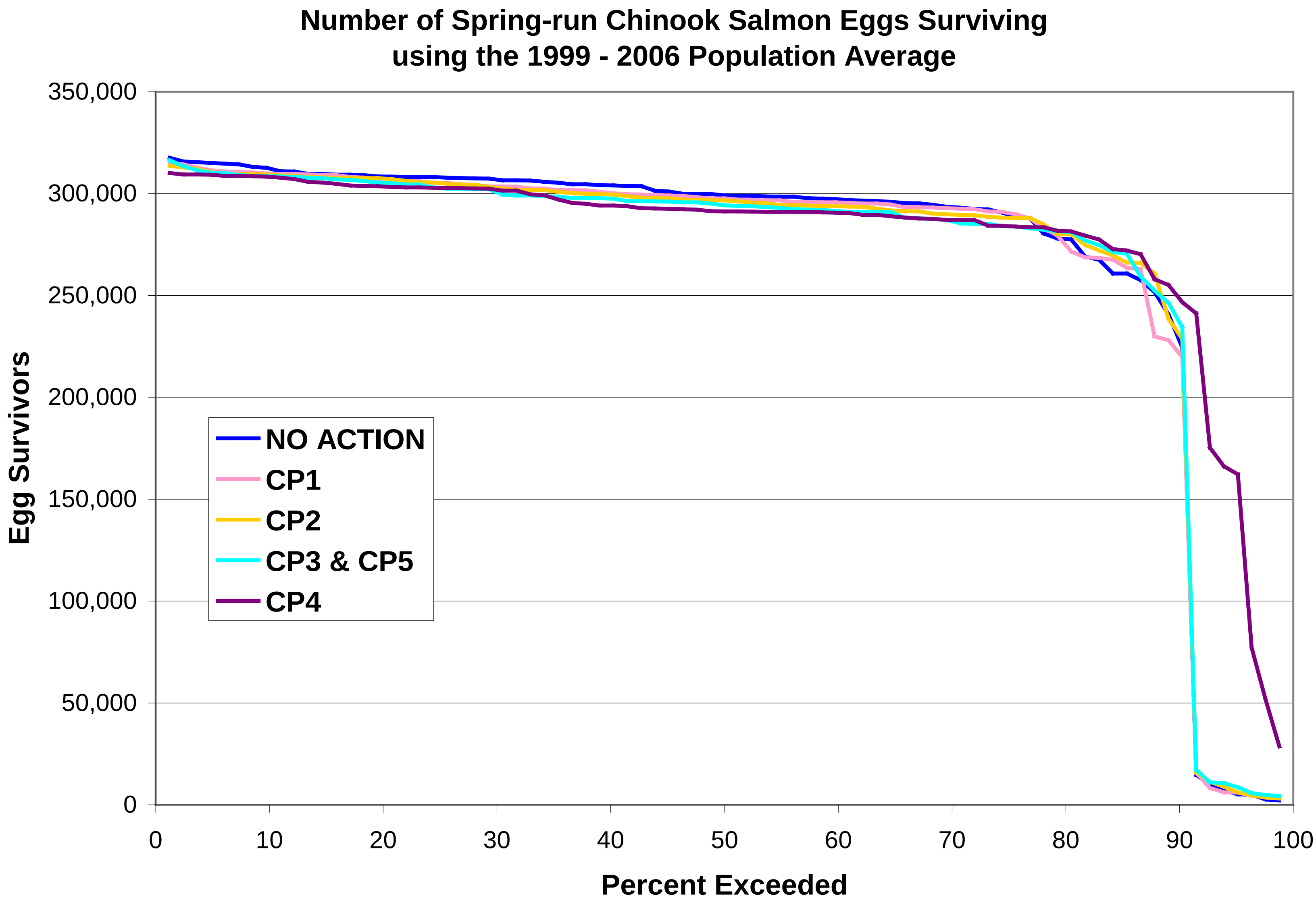

Figure B-17A. Frequency distribution of the number of spring-run Chinook salmon egg survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

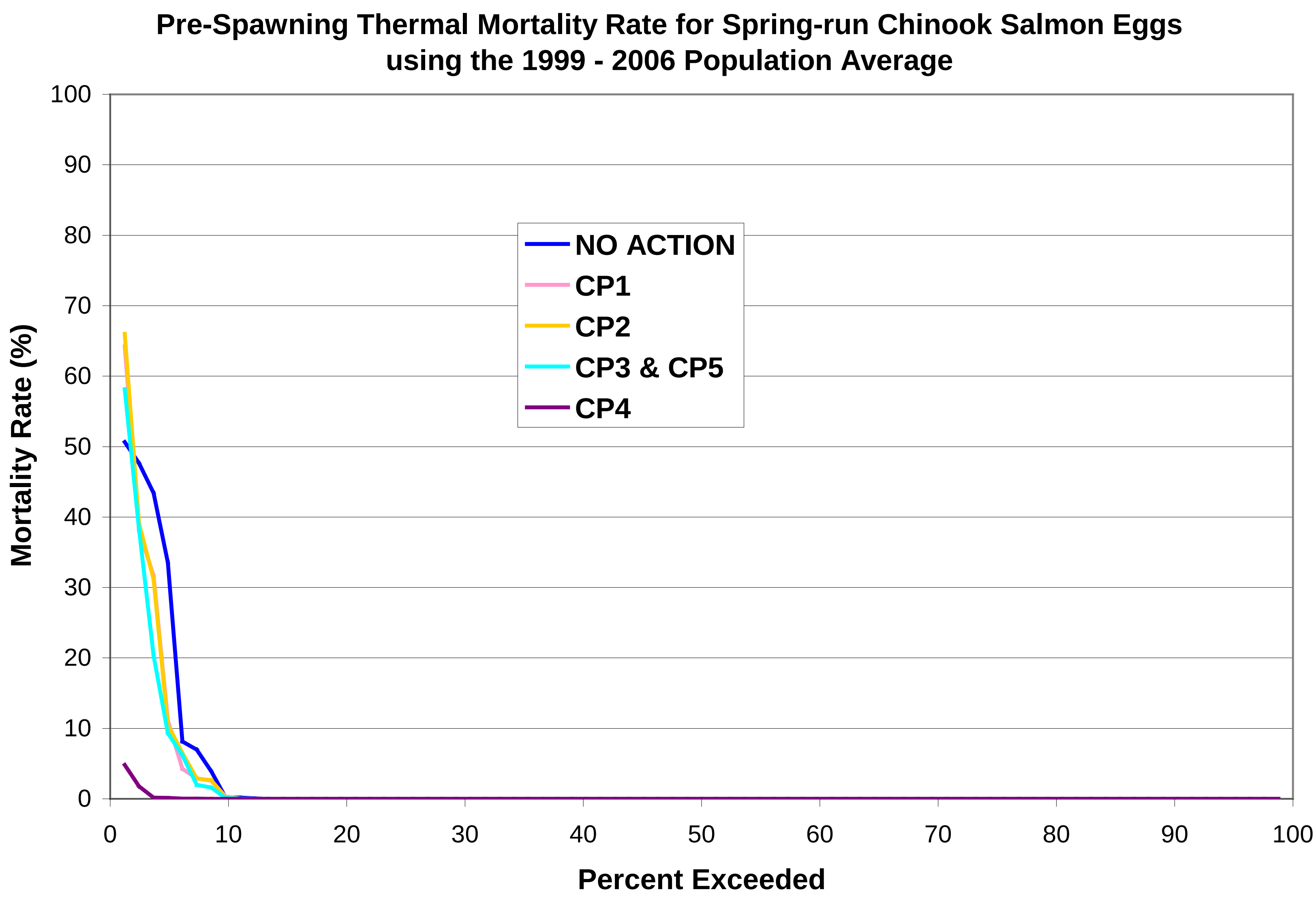

Figure B-17B. Frequency distribution of the pre-spawning thermal mortality rate of spring-run Chinook salmon eggs (*in vivo*) during the 1921-2003 simulation period based on the 1999-2006 population average.

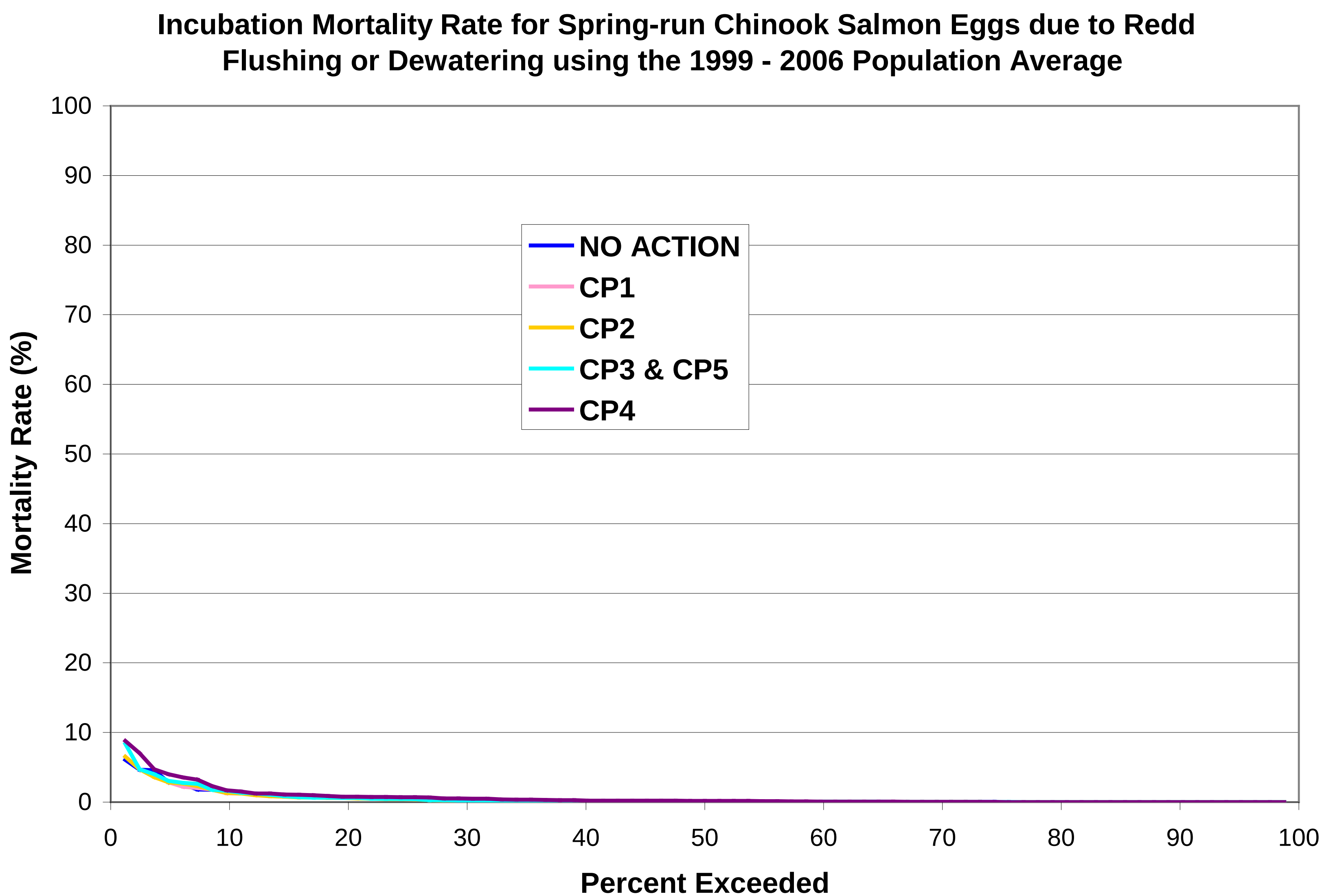

Figure B-17C. Frequency distribution of the incubation mortality rate (mortality due to the flushing or dewatering if redds) of spring-run Chinook salmon eggs during the 1921-2003 simulation period based on the 1999-2006 population average.

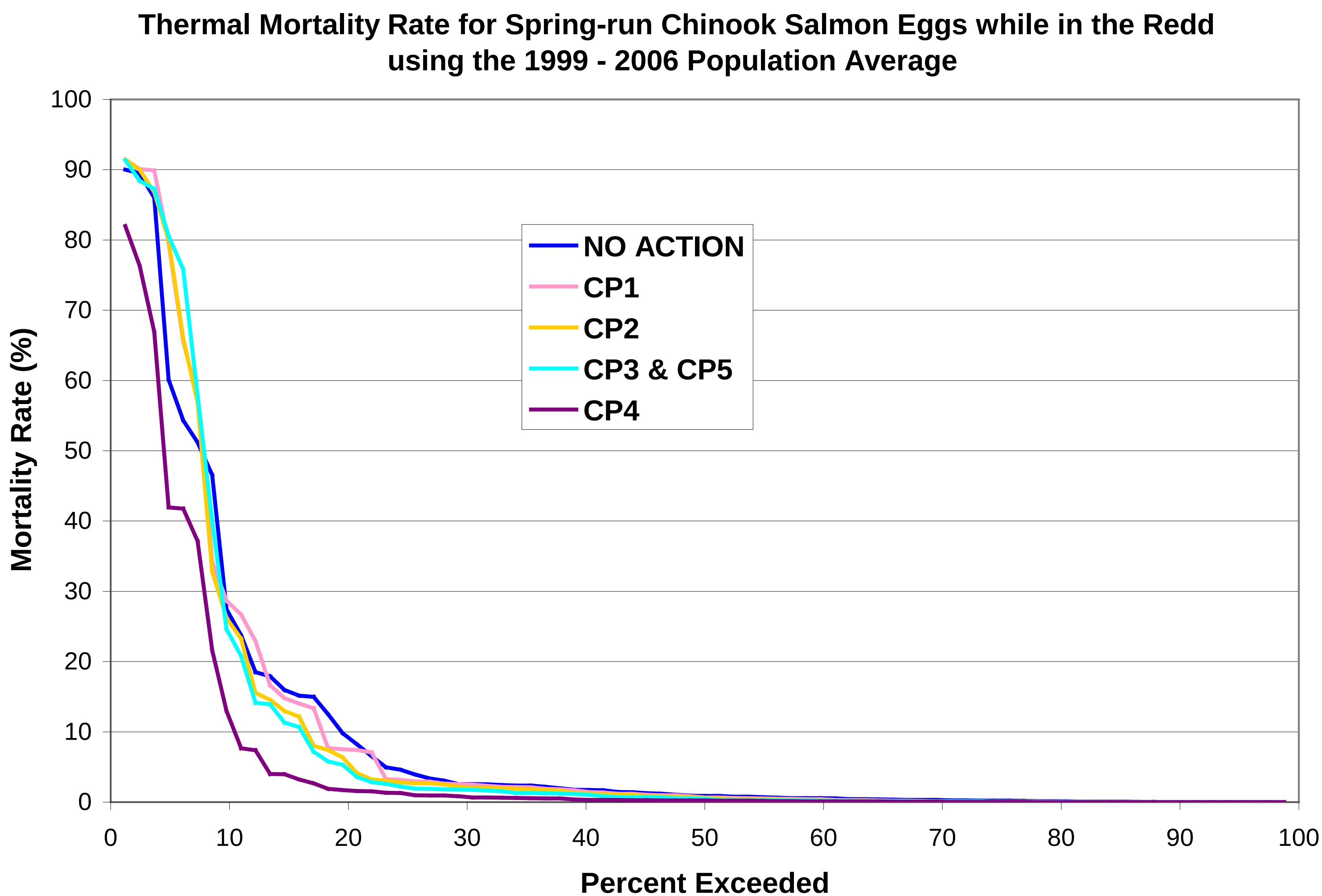

Figure B-17D. Frequency distribution of the thermal mortality rate of spring-run Chinook salmon eggs while in the redd during the 1921-2003 simulation period based on the 1999-2006 population average.

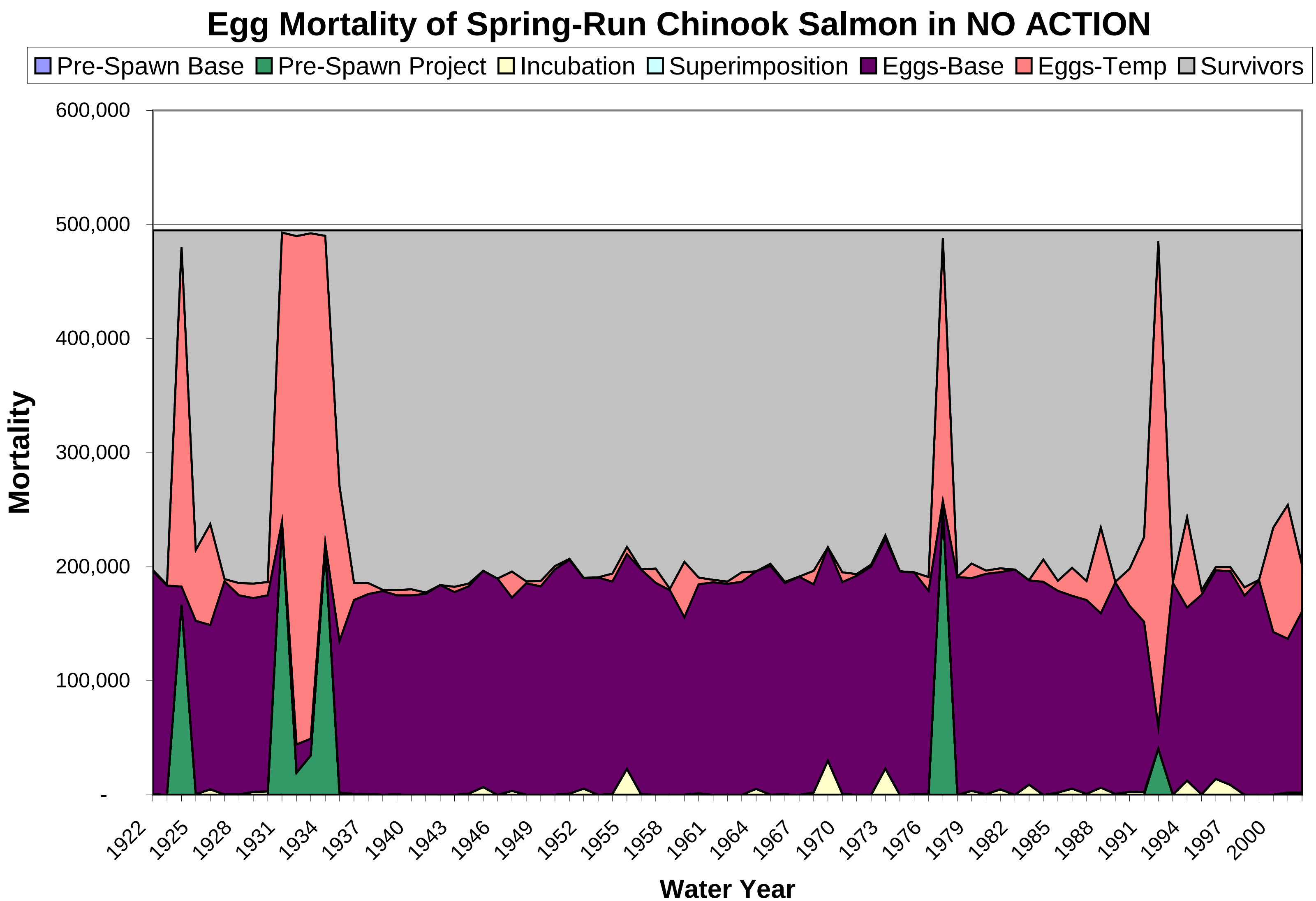

Figure B-18A. Source of mortality of spring-run Chinook salmon eggs in NO ACTION based on the 1999-2006 population average.

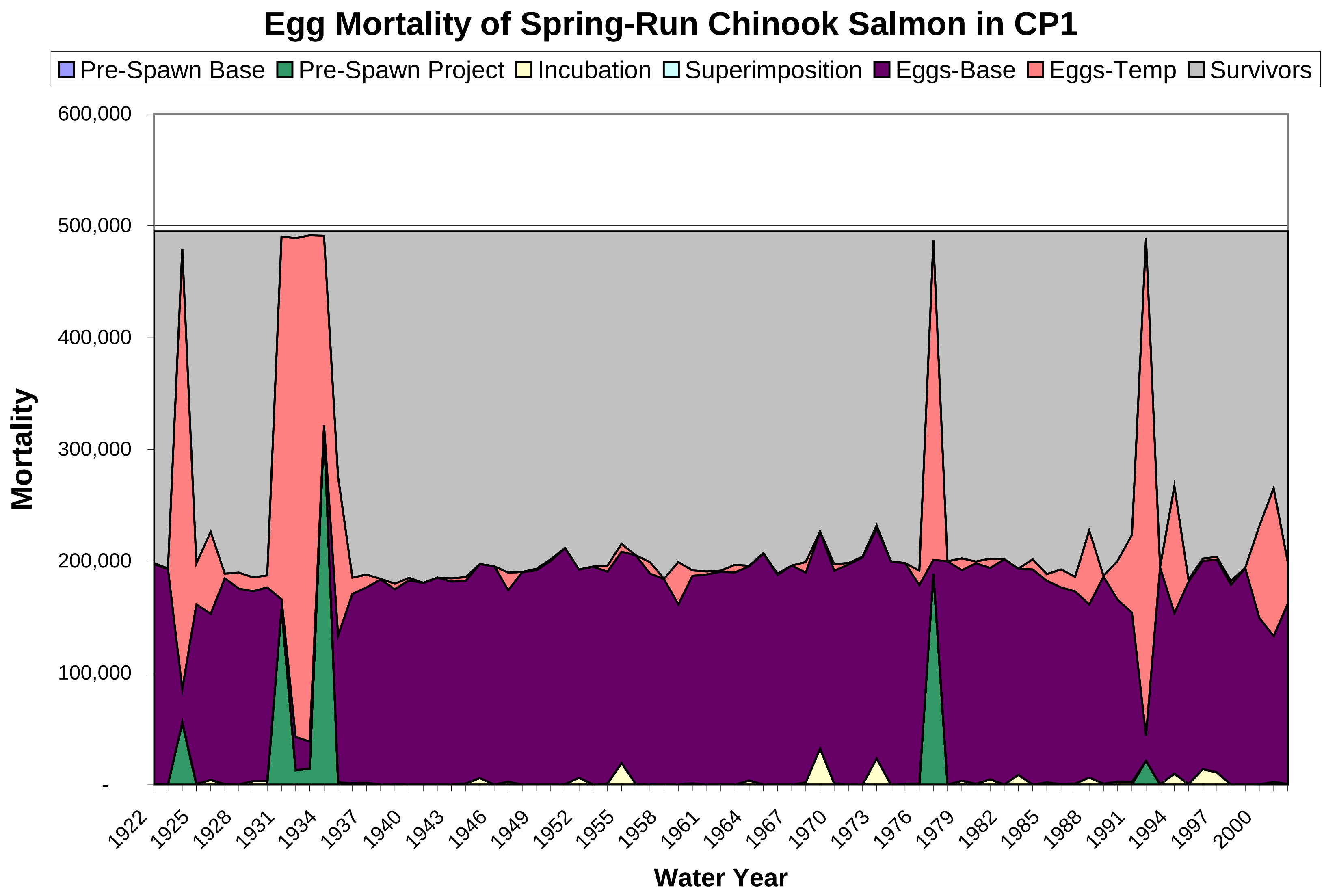

Figure B-18B. Source of mortality of spring-run Chinook salmon eggs in CP1 based on the 1999-2006 population average.

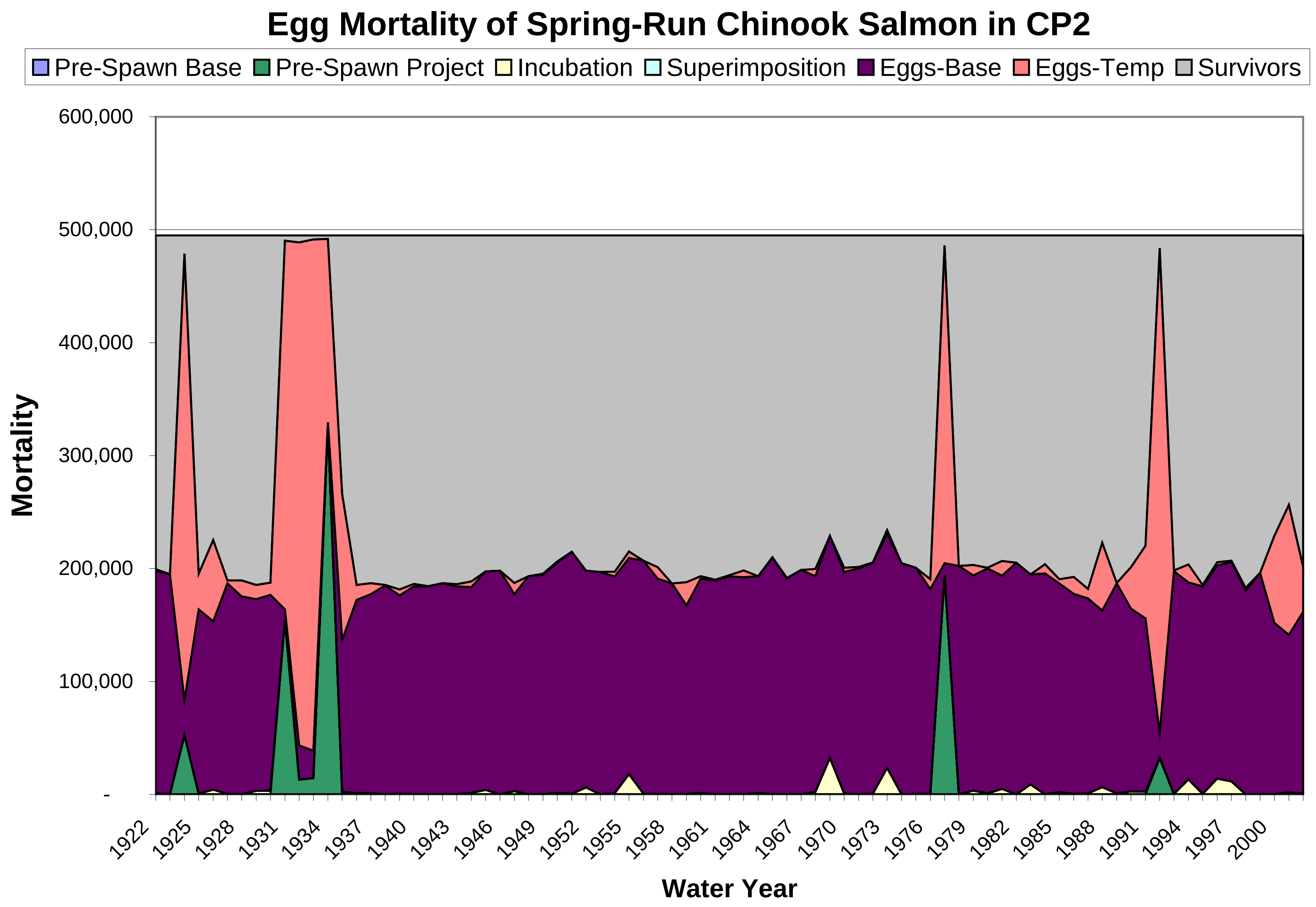

Figure B-18C. Source of mortality of spring-run Chinook salmon eggs in CP2 based on the 1999-2006 population average.

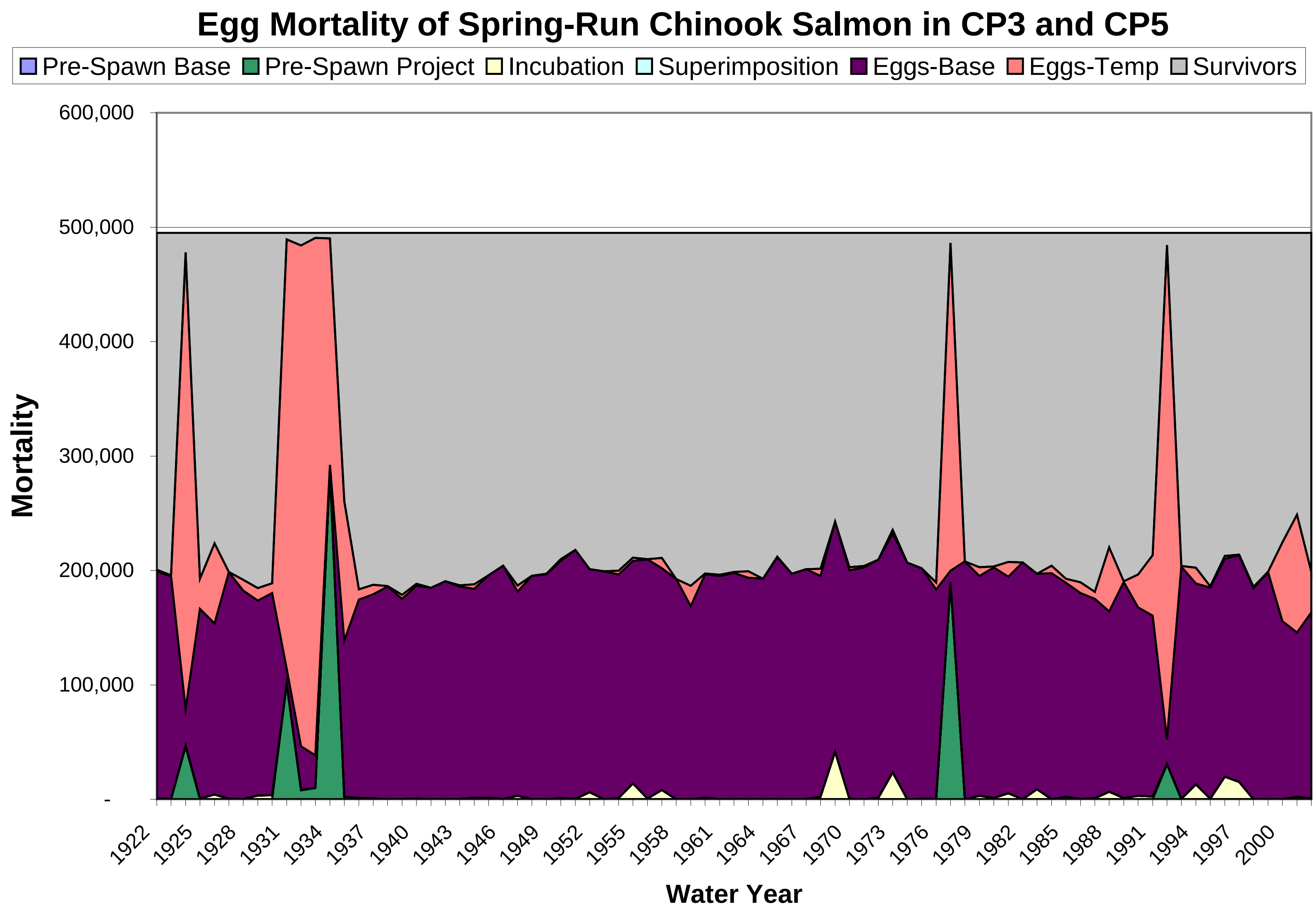

Figure B-18D. Source of mortality of spring-run Chinook salmon eggs in CP3 and CP5 based on the 1999-2006 population average.

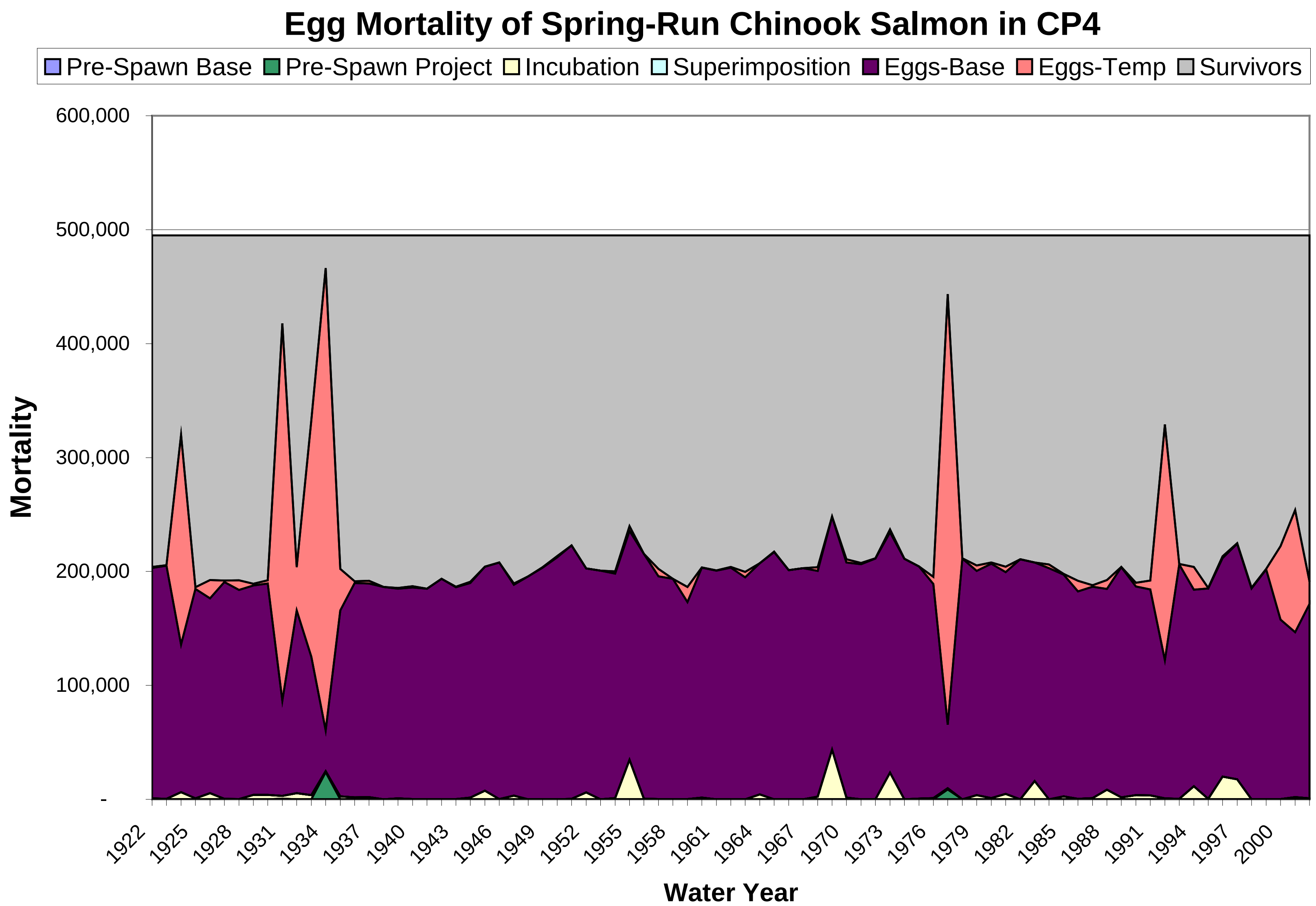

Figure B-18E. Source of mortality of spring-run Chinook salmon eggs in CP4 based on the 1999-2006 population average.

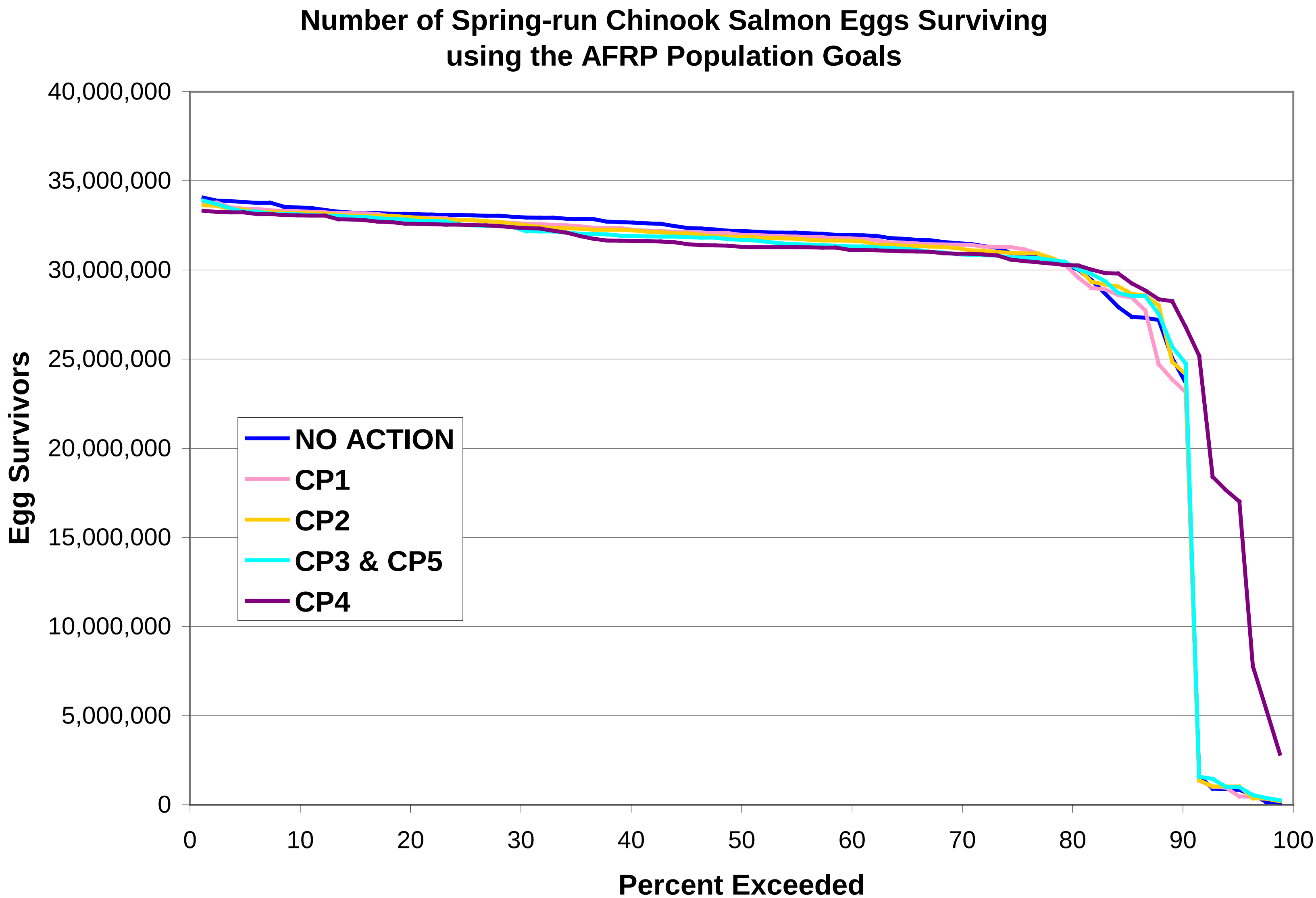

Figure B-19A. Frequency distribution of the number of spring-run Chinook salmon egg survivors during the 1921-2003 simulation period based on the AFRP population goals.

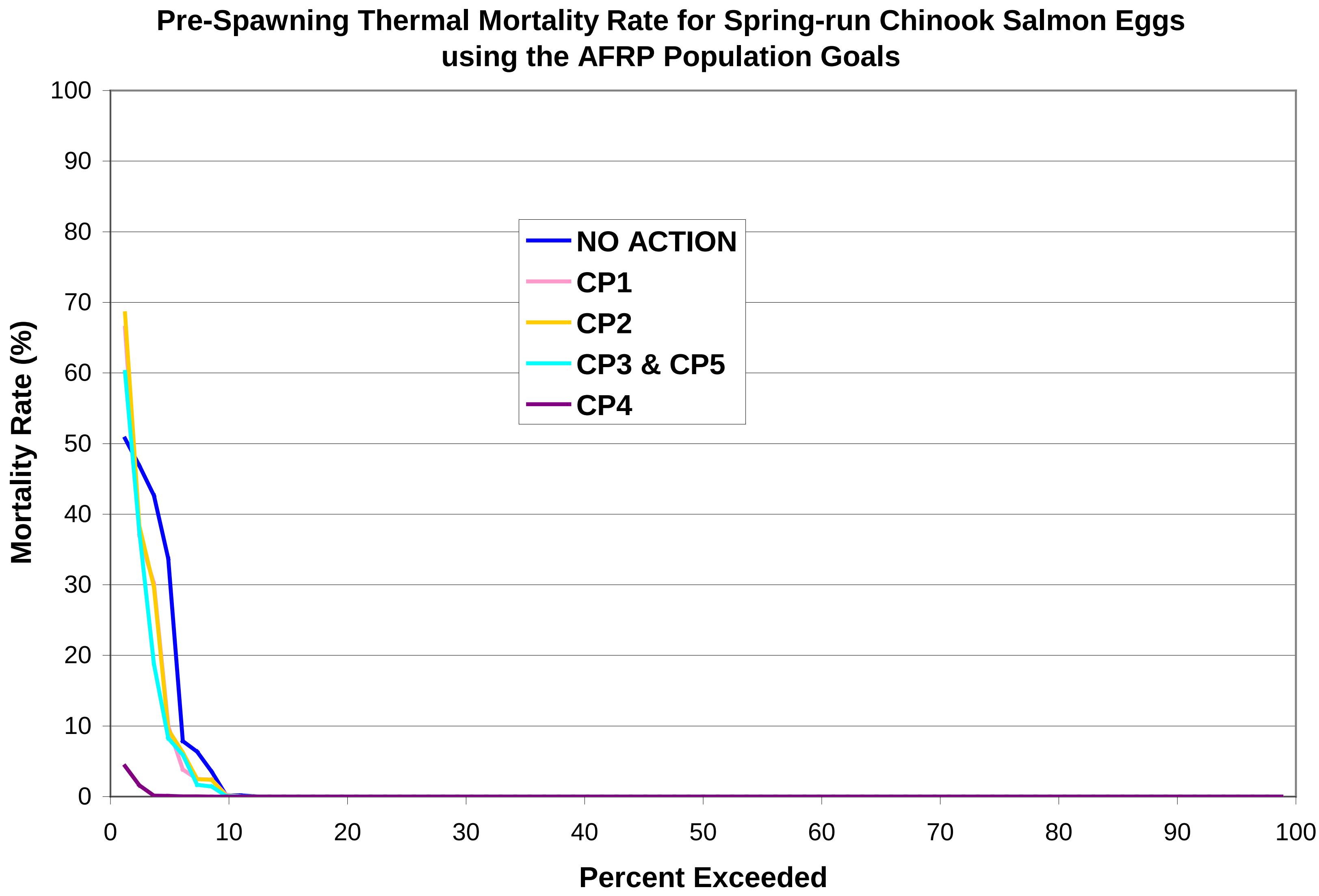

Figure B-19B. Frequency distribution of the pre-spawning thermal mortality rate of spring-run Chinook salmon eggs (*in vivo*) during the 1921-2003 simulation period based on the AFRP population goals.

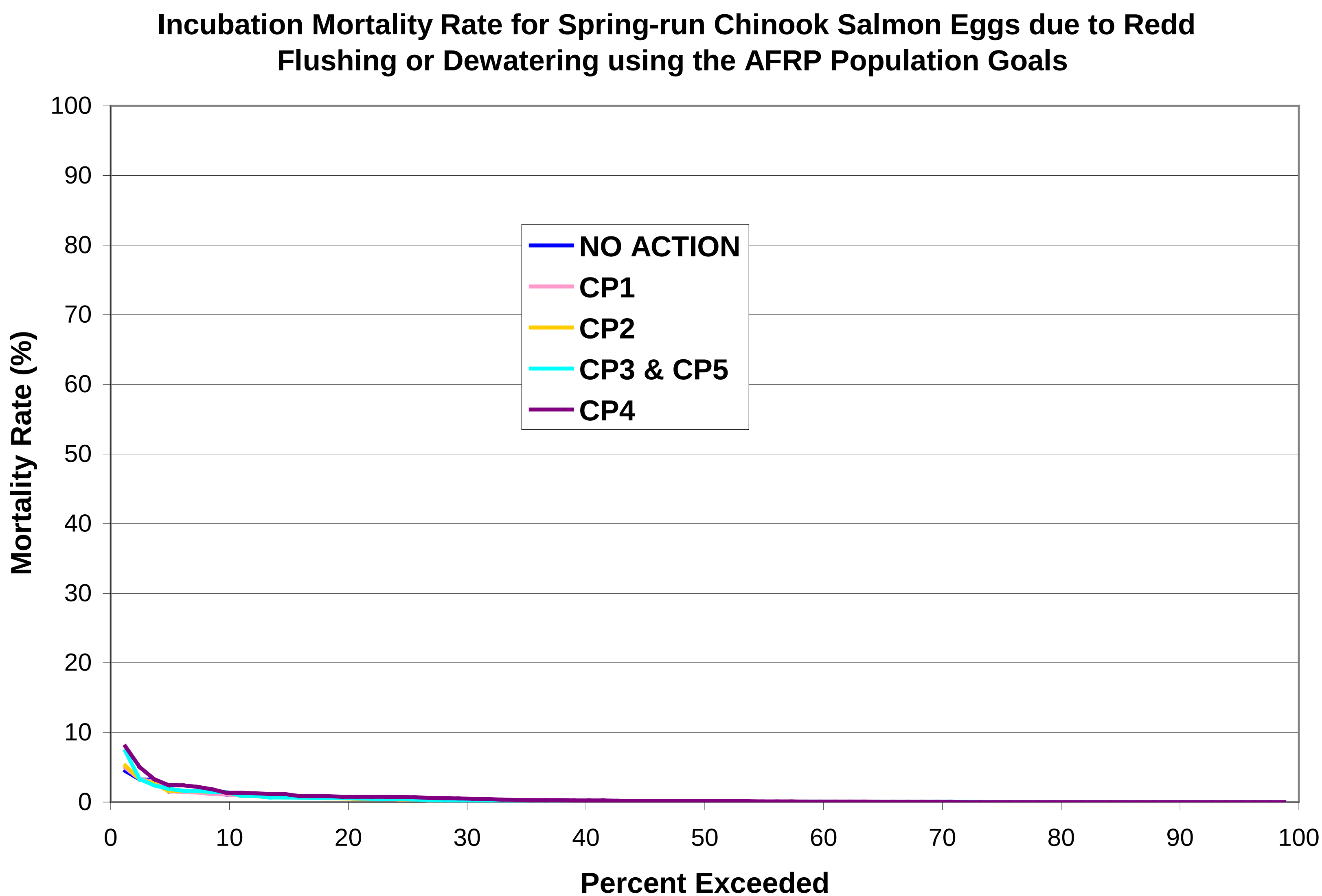

Figure B-19C. Frequency distribution of the incubation mortality rate (mortality due to the flushing or dewatering of eggs) of spring-run Chinook salmon eggs during the 1921-2003 simulation period based on the AFRP population goals.

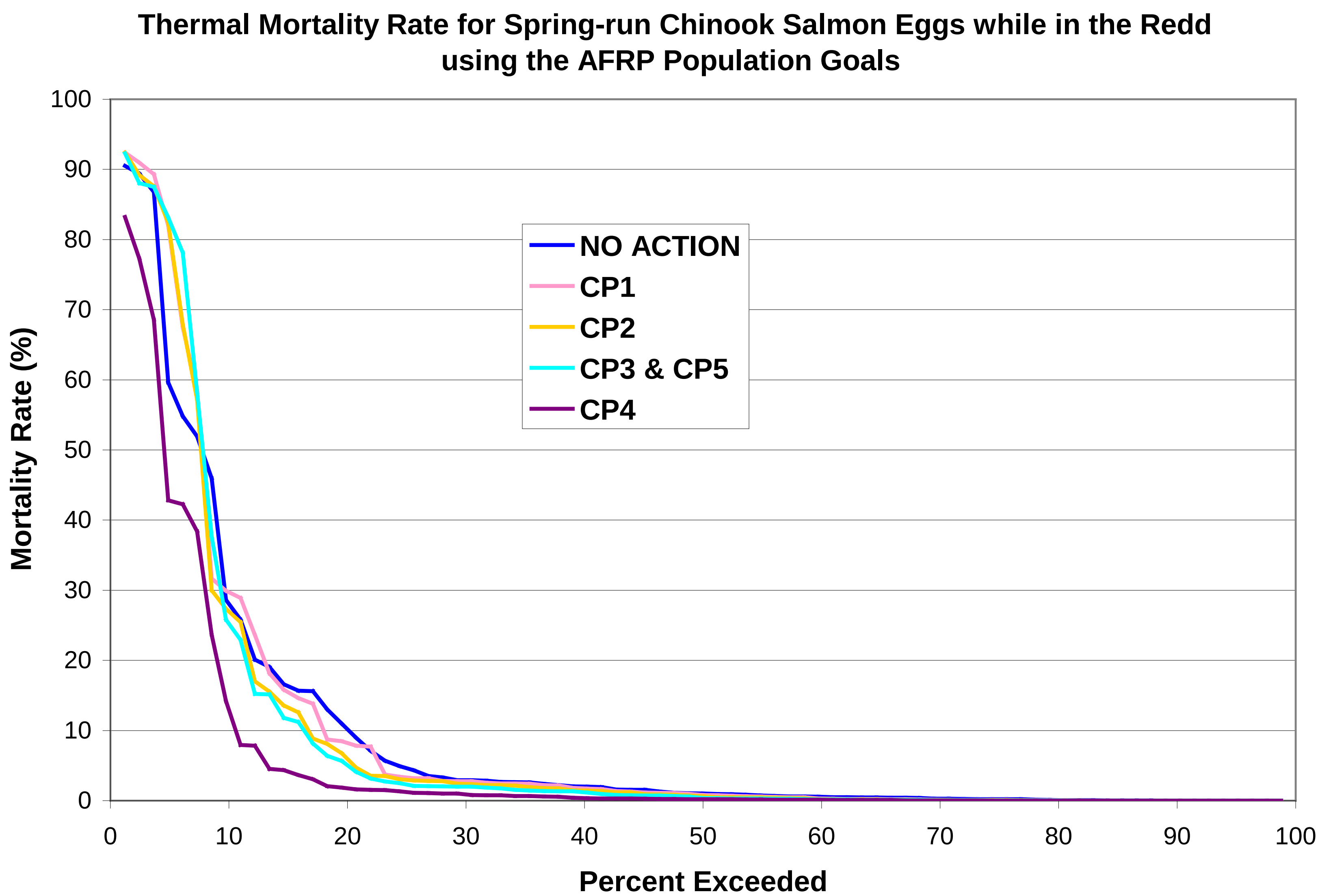

Figure B-19D. Frequency distribution of the thermal mortality rate of spring-run Chinook salmon eggs while in the redd during the 1921-2003 simulation period based on the AFRP population goals.

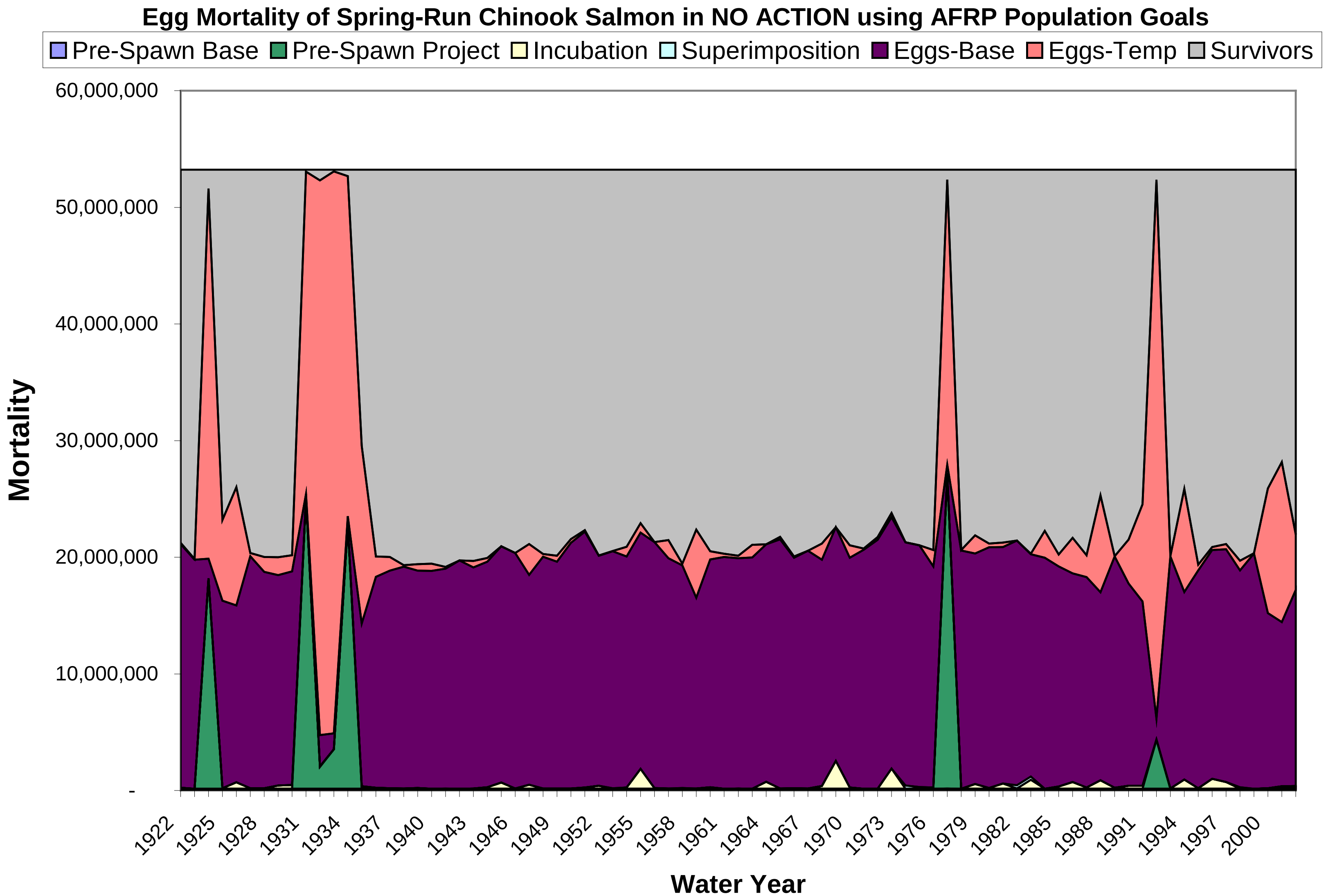

Figure B-20A. Source of mortality of spring-run Chinook salmon eggs in NO ACTION based on the AFRP population goals.

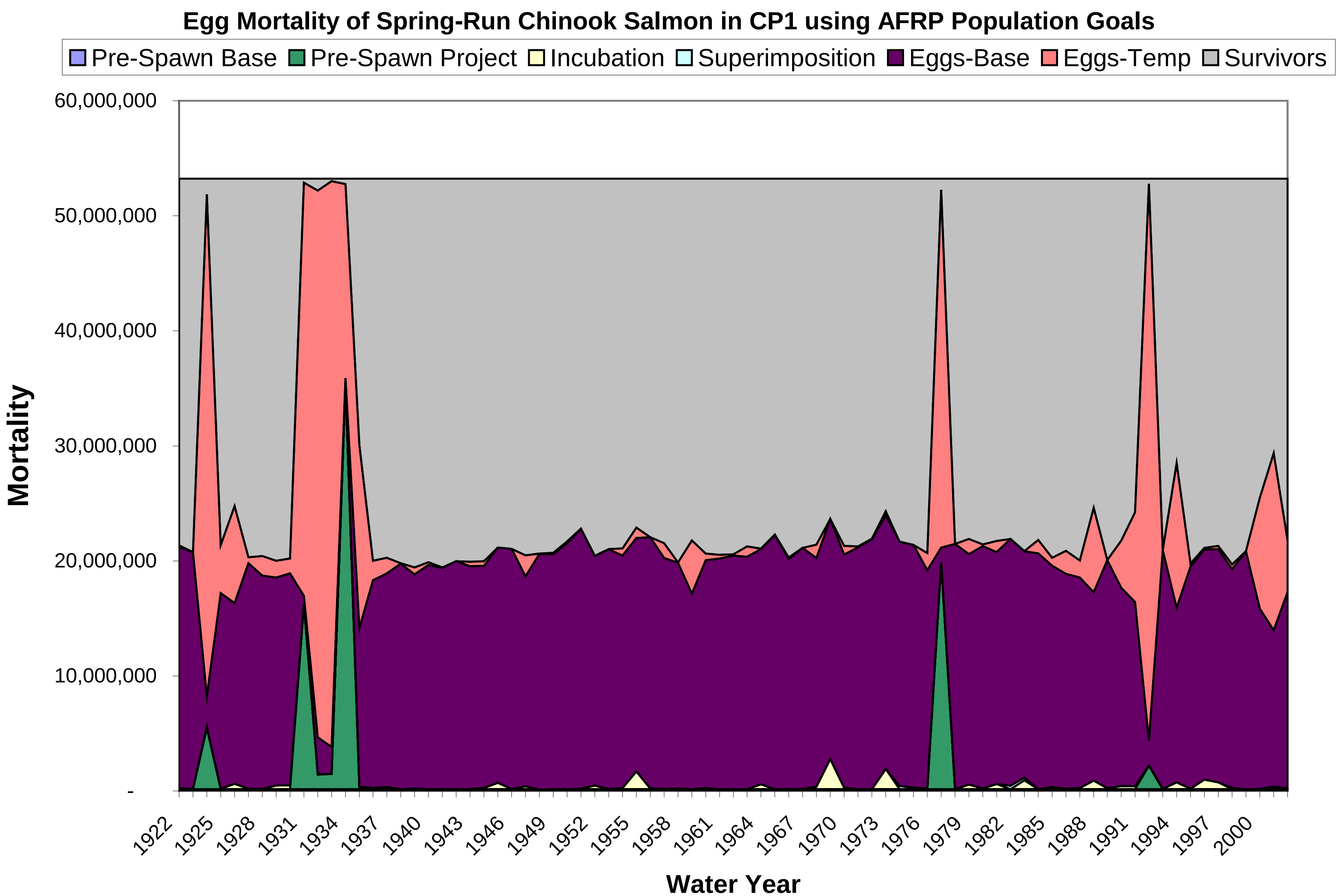

Figure B-20B. Source of mortality of spring-run Chinook salmon eggs in CP1 based on the AFRP population goals.

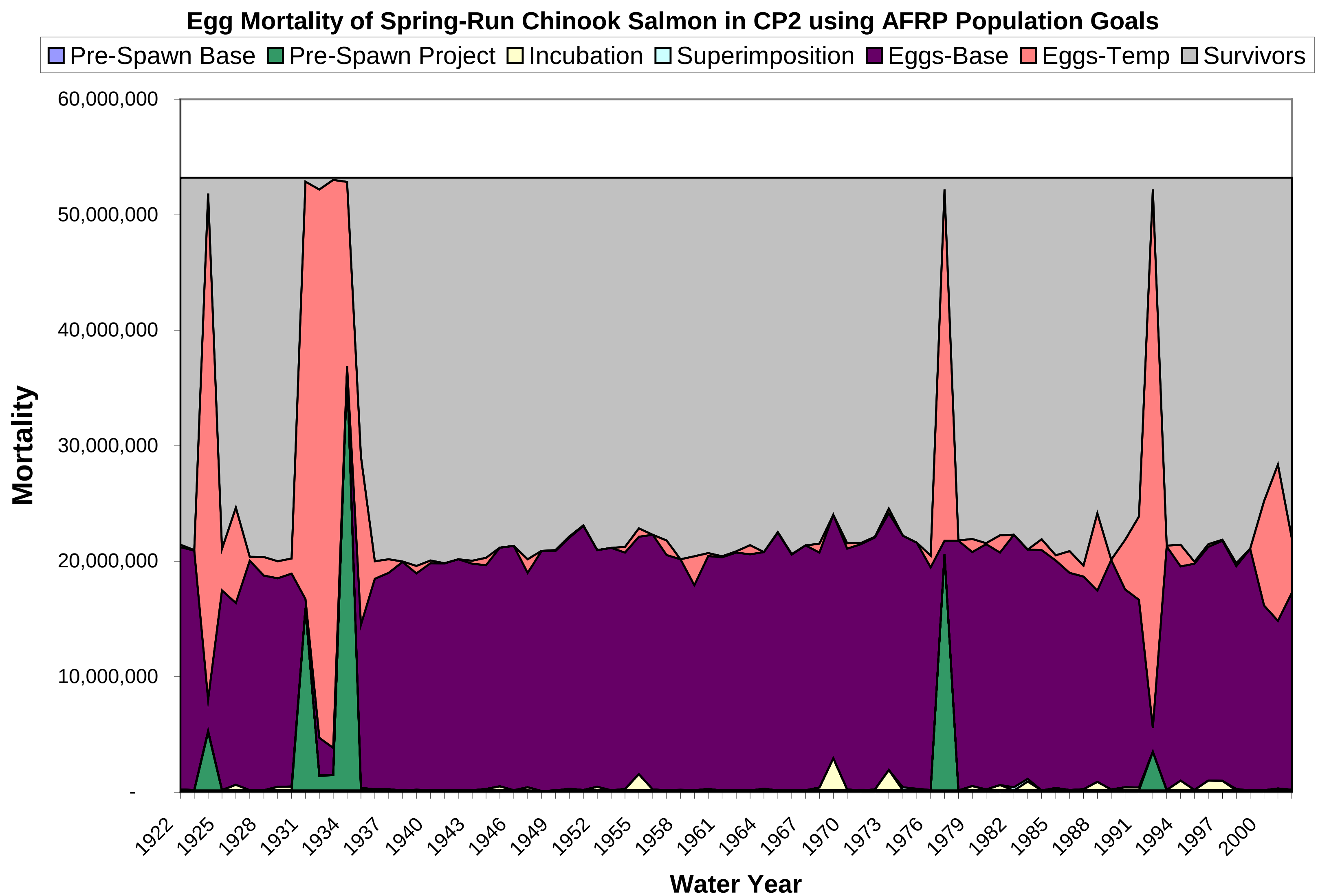

Figure B-20C. Source of mortality of spring-run Chinook salmon eggs in CP2 based on the AFRP population goals.

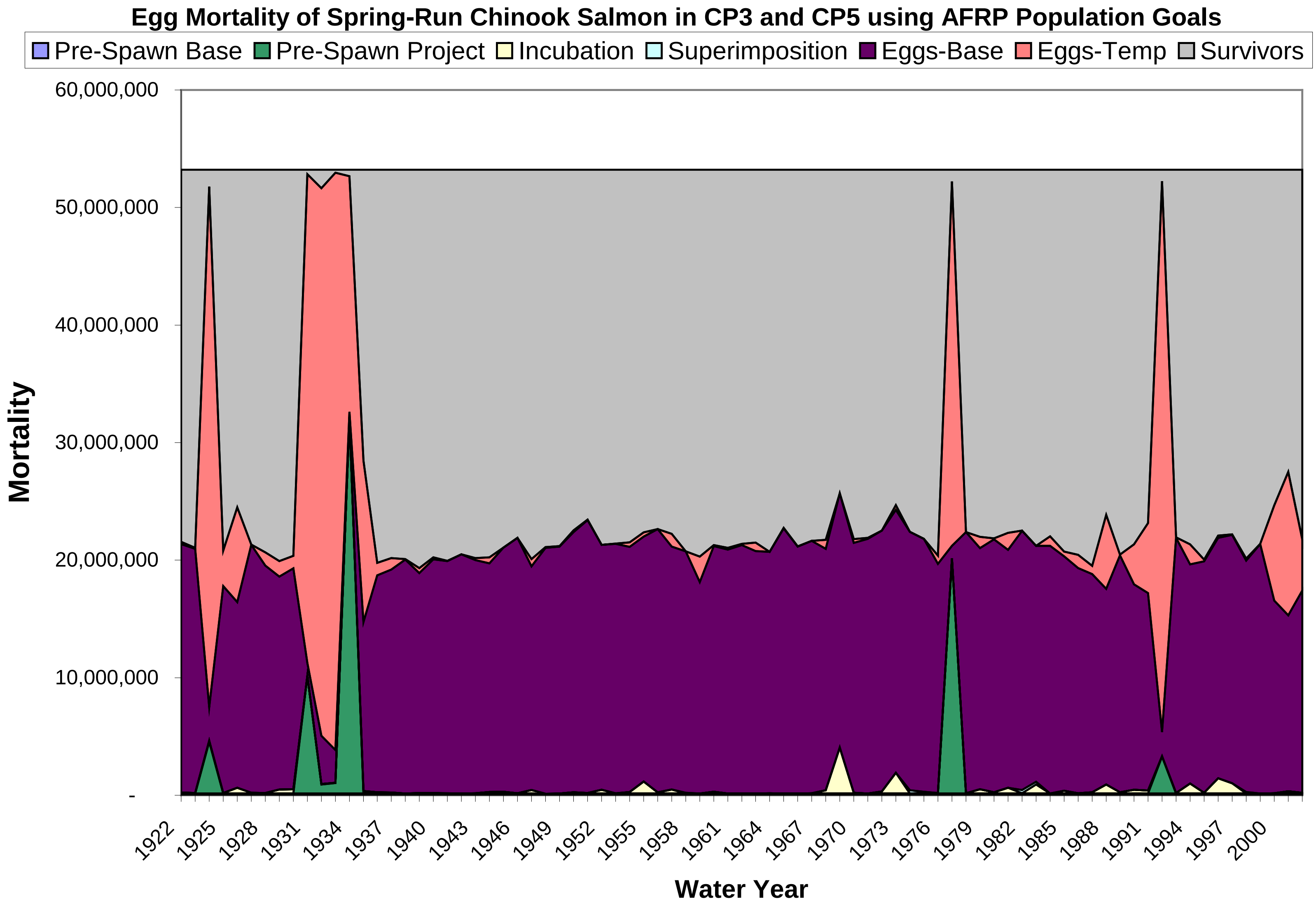

Figure B-20D. Source of mortality of spring-run Chinook salmon eggs in CP3 and CP5 based on the AFRP population goals.

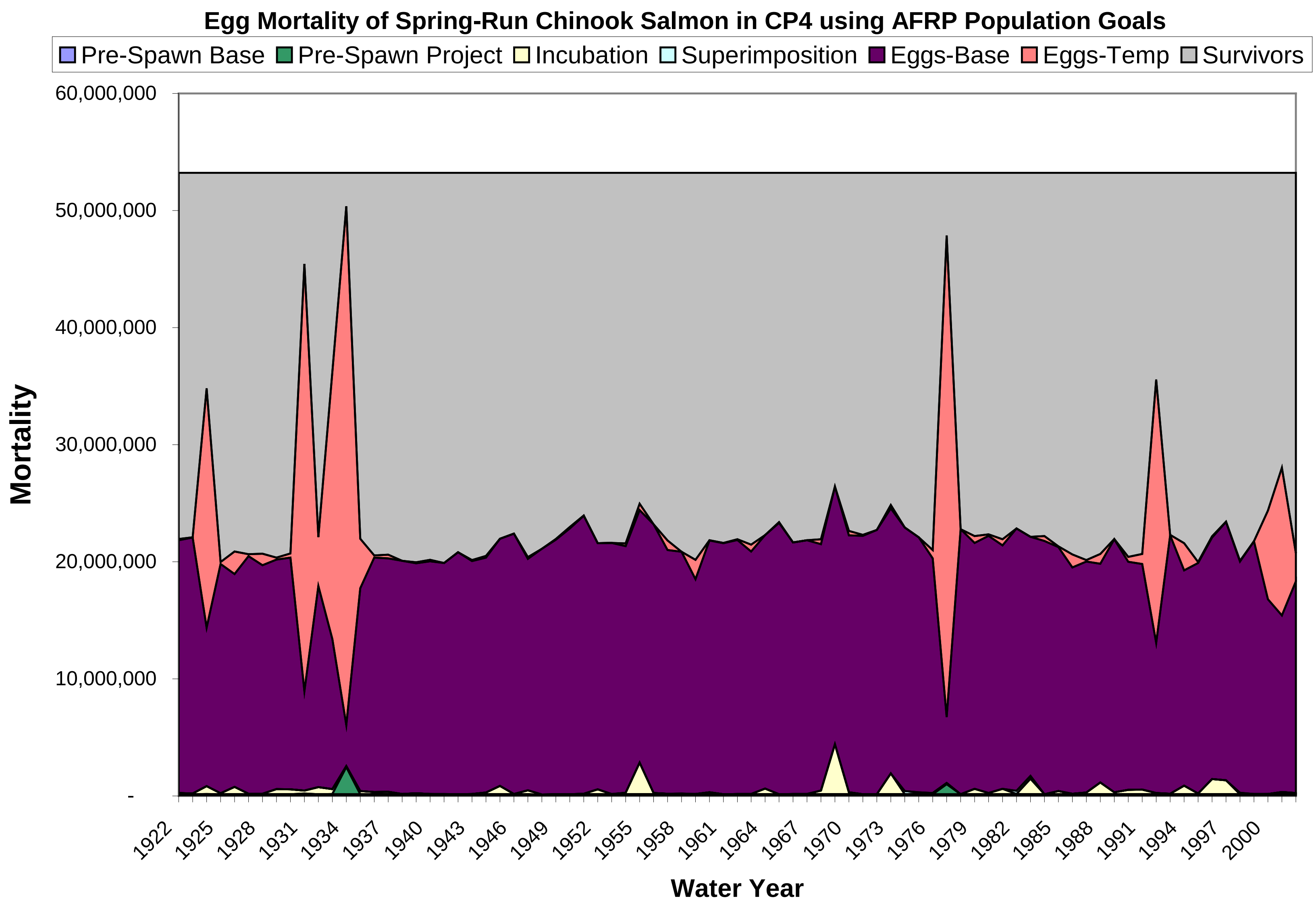

Figure B-20E. Source of mortality of spring-run Chinook salmon eggs in CP4 based on the AFRP population goals.

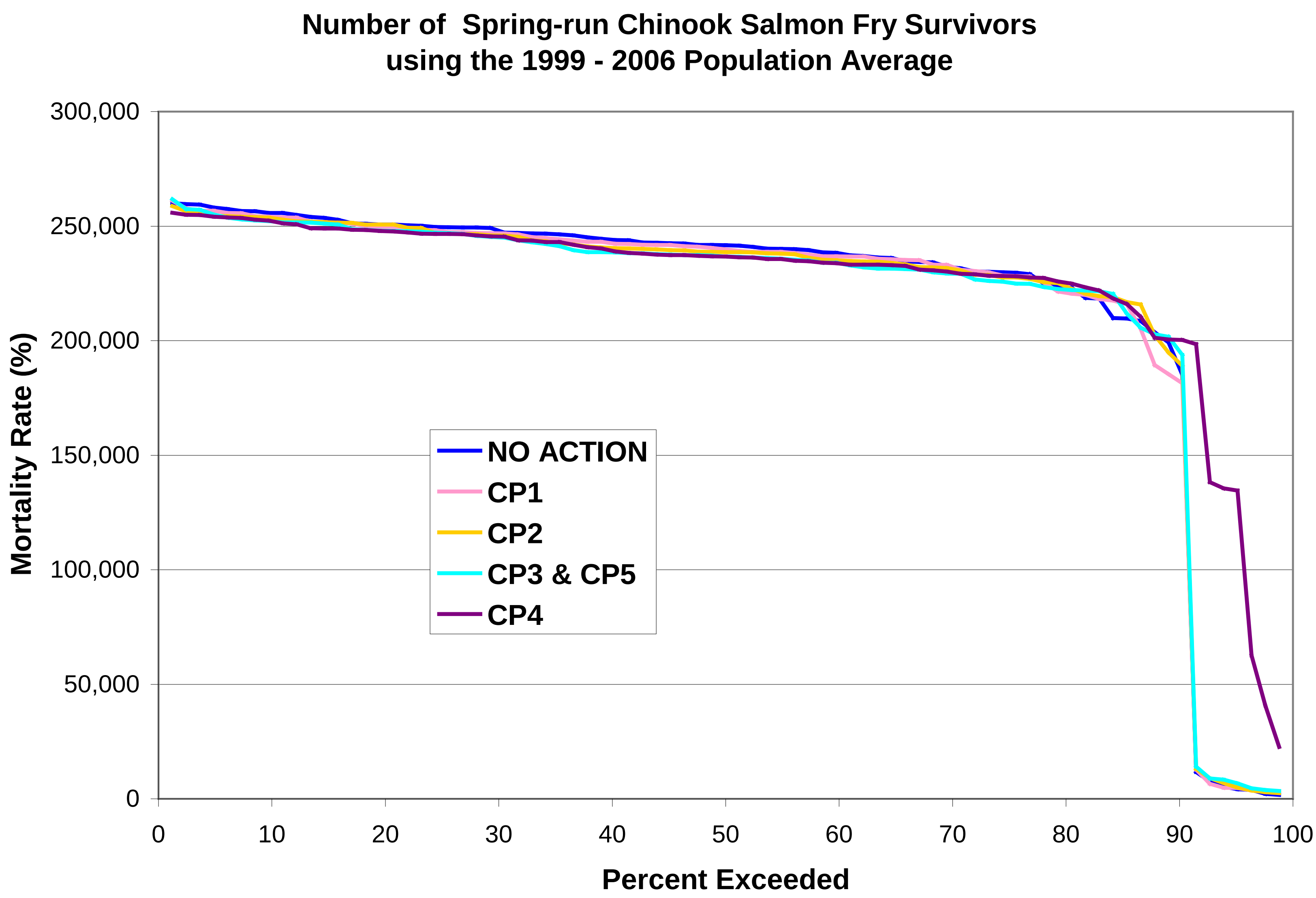

Figure B-21A. Frequency distribution of the number of spring-run Chinook salmon fry survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

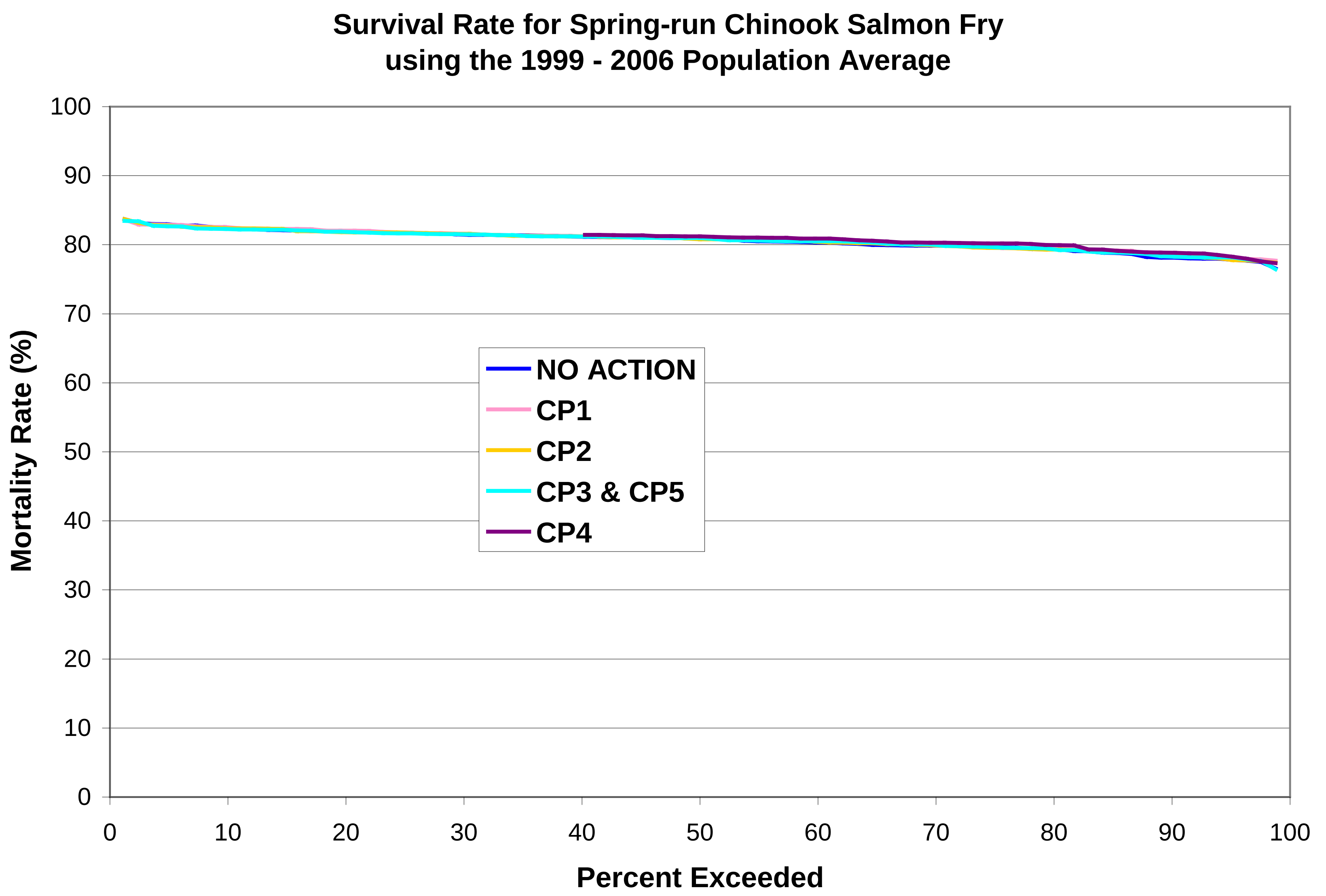

Figure B-21B. Frequency distribution of the survival rate of spring-run Chinook salmon fry during the 1921-2003 simulation period based on the 1999-2006 population average.

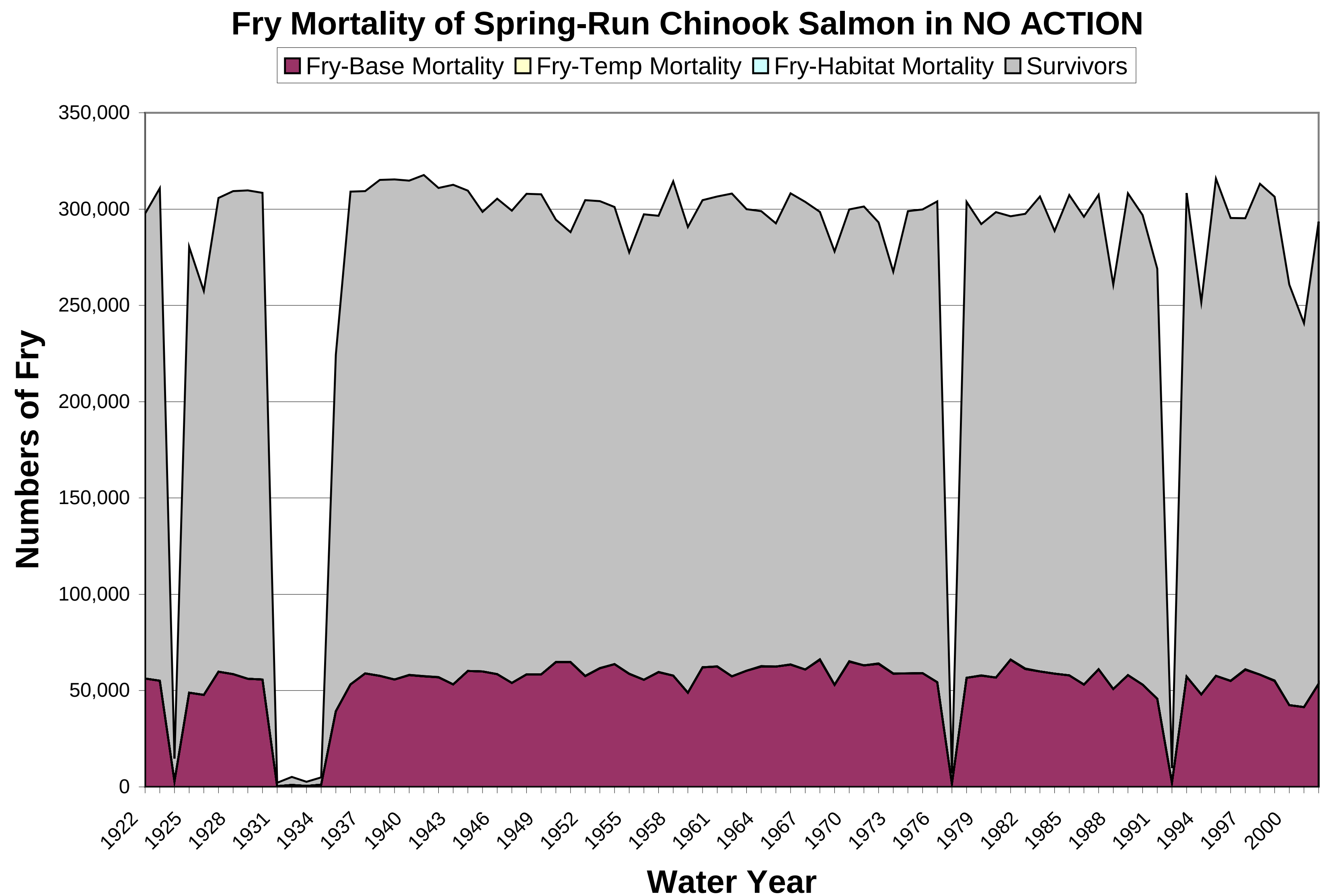

Figure B-22A. Source of mortality of spring-run Chinook salmon fry in NO ACTION based on the 1999-2006 population average.

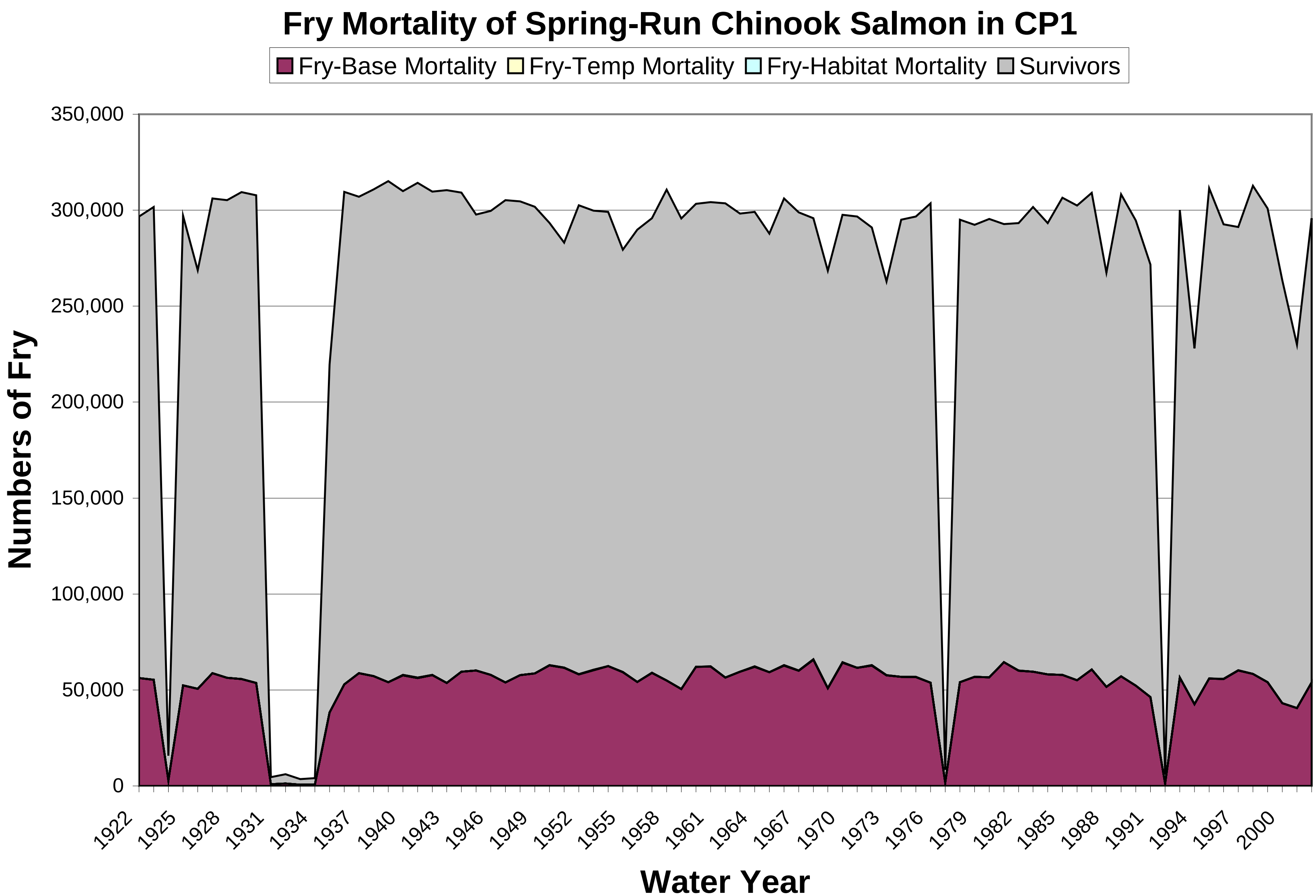

Figure B-22B. Source of mortality of spring-run Chinook salmon fry in CP1 based on the 1999-2006 population average.

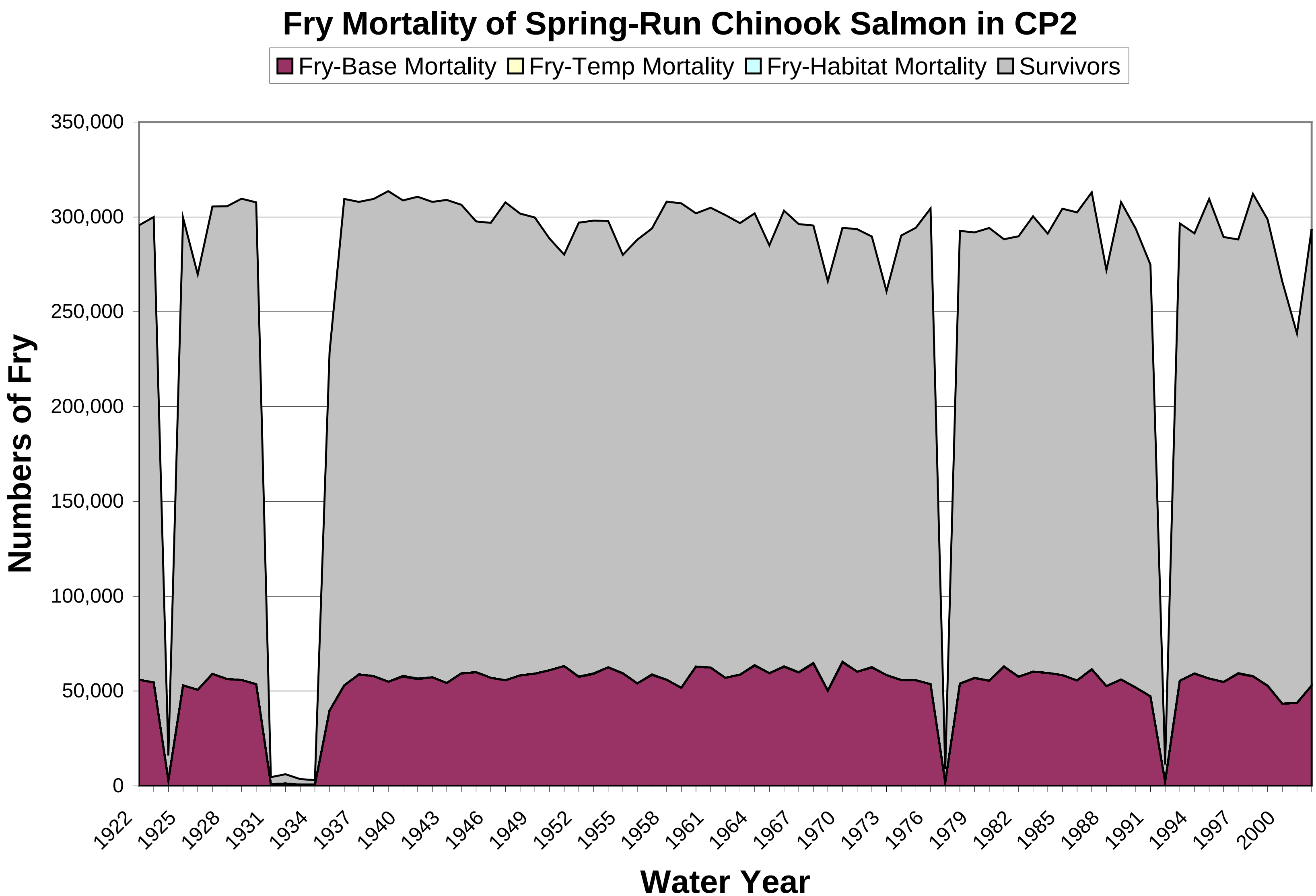

Figure B-22C. Source of mortality of spring-run Chinook salmon fry in CP2 based on the 1999-2006 population average.

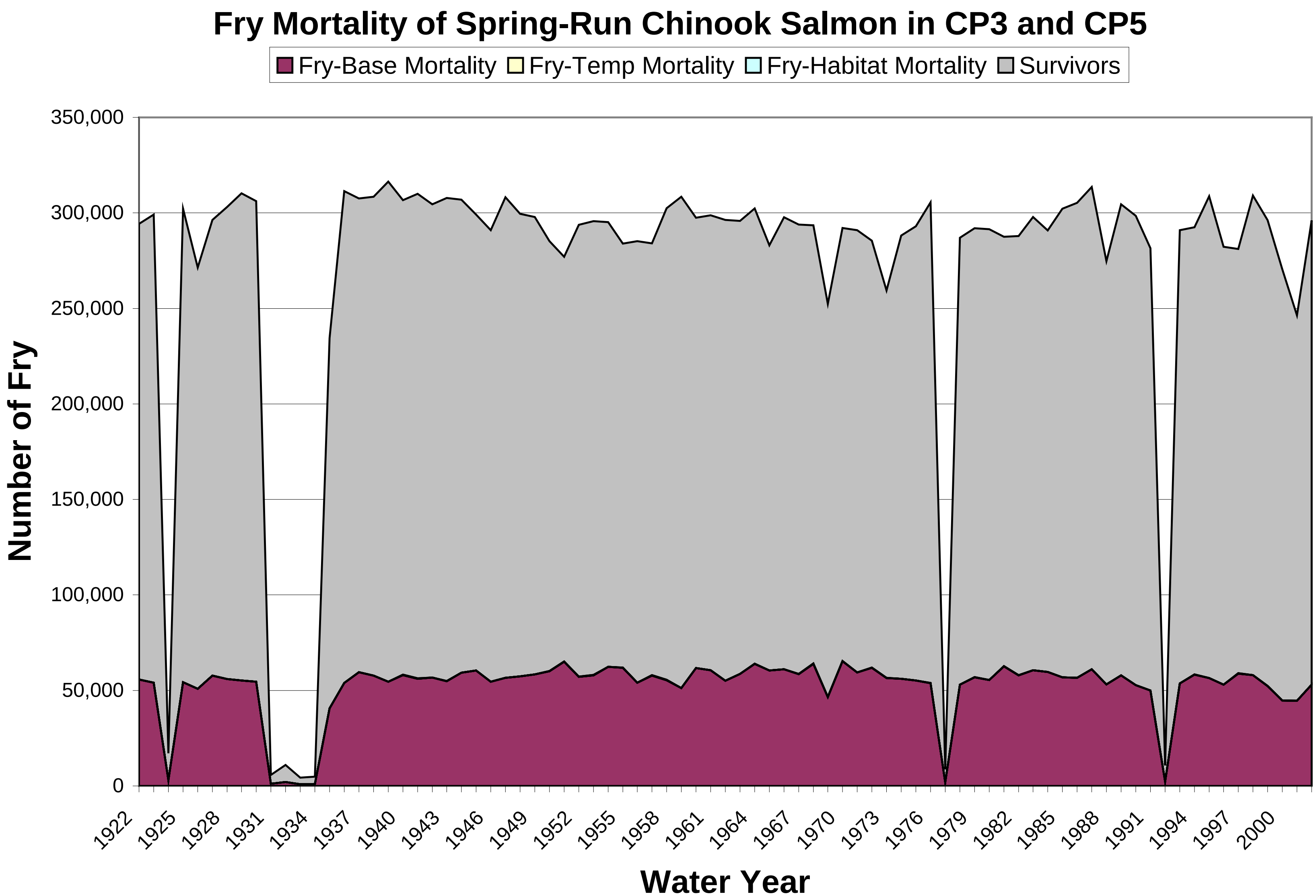

Figure B-22D. Source of mortality of spring-run Chinook salmon fry in CP3 and CP5 based on the 1999-2006 population average.

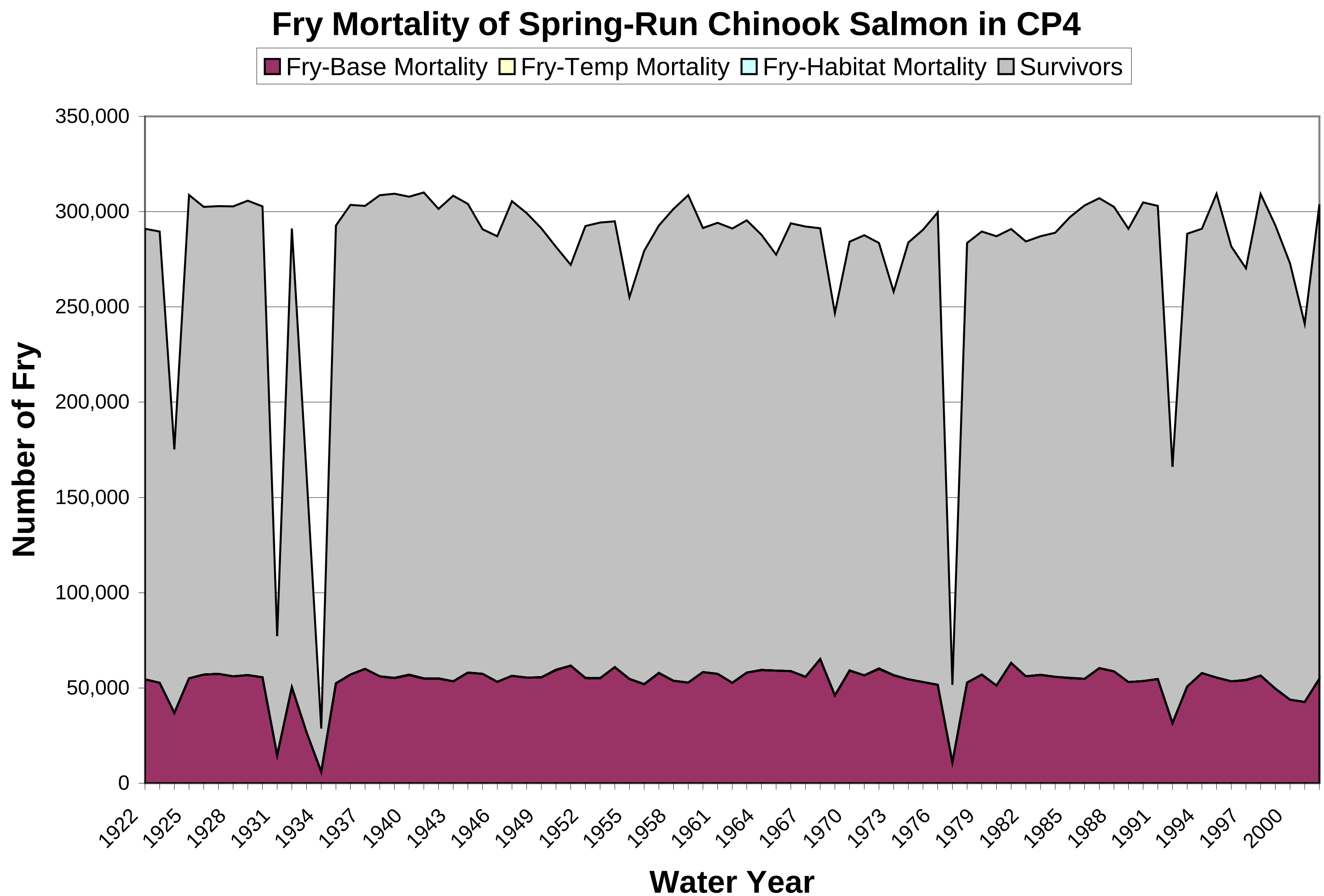

Figure B-22E. Source of mortality of spring-run Chinook salmon fry in CP4 based on the 1999-2006 population average.

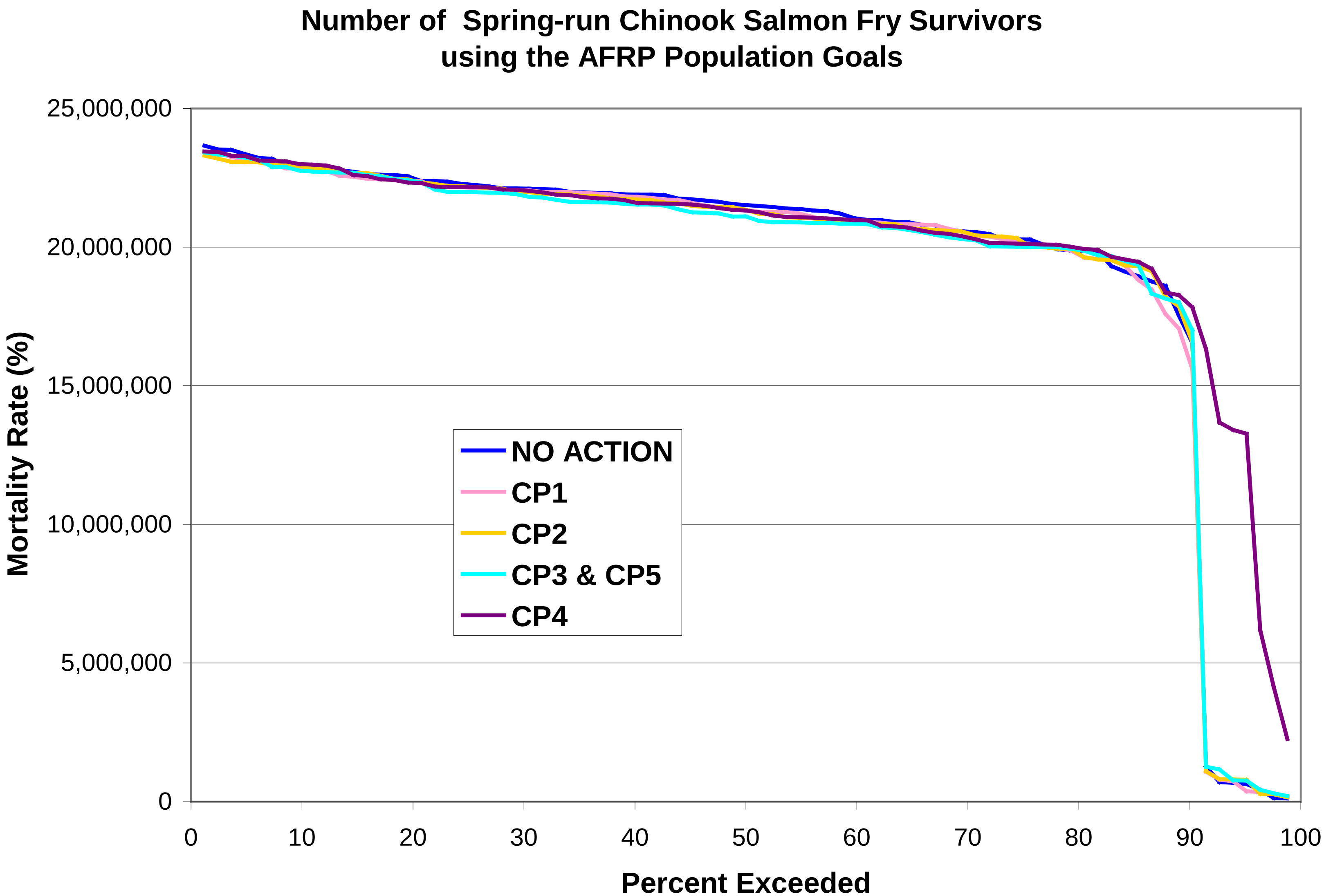

Figure B-23A. Frequency distribution of the number of spring-run Chinook salmon fry survivors during the 1921-2003 simulation period based on the AFRP population goals.

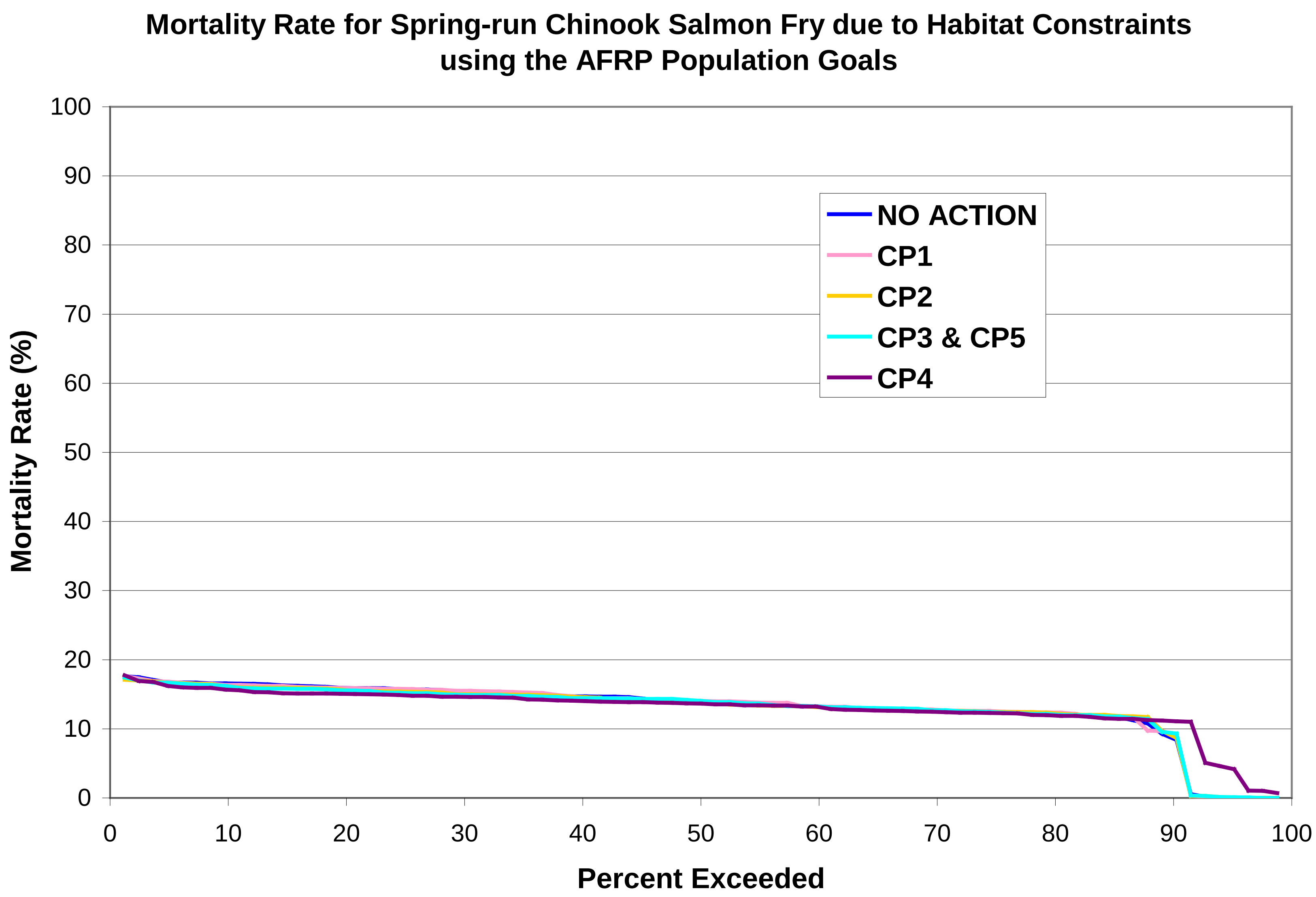

Figure B-23B. Frequency distribution of the mortality rate of spring-run Chinook salmon fry due to habitat constraints (forced movement due to flows or fish density) during the 1921-2003 simulation period based on the AFRP population goals.

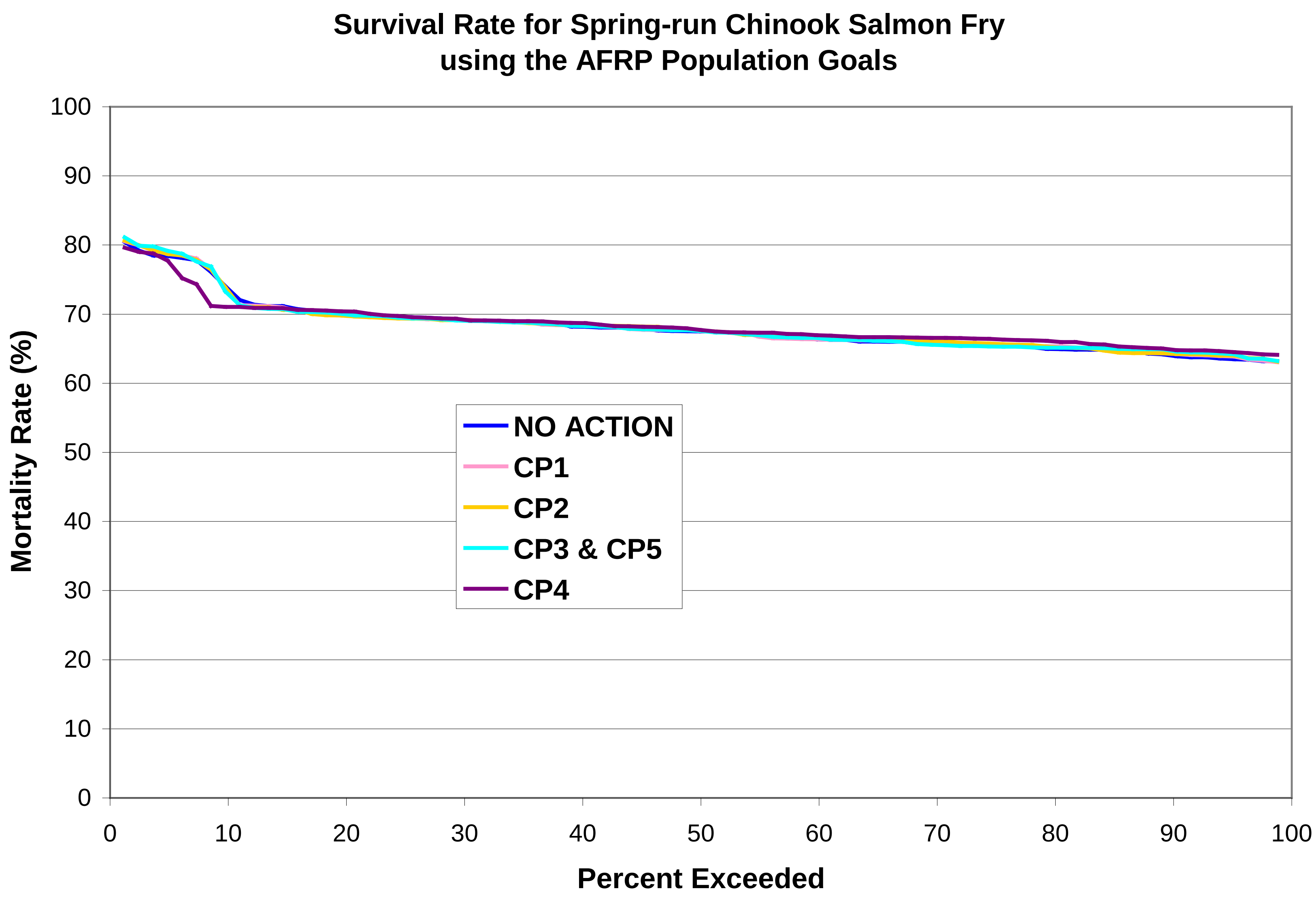

Figure B-23C. Frequency distribution of the survival rate of spring-run Chinook salmon fry during the 1921-2003 simulation period based on the AFRP population goals.

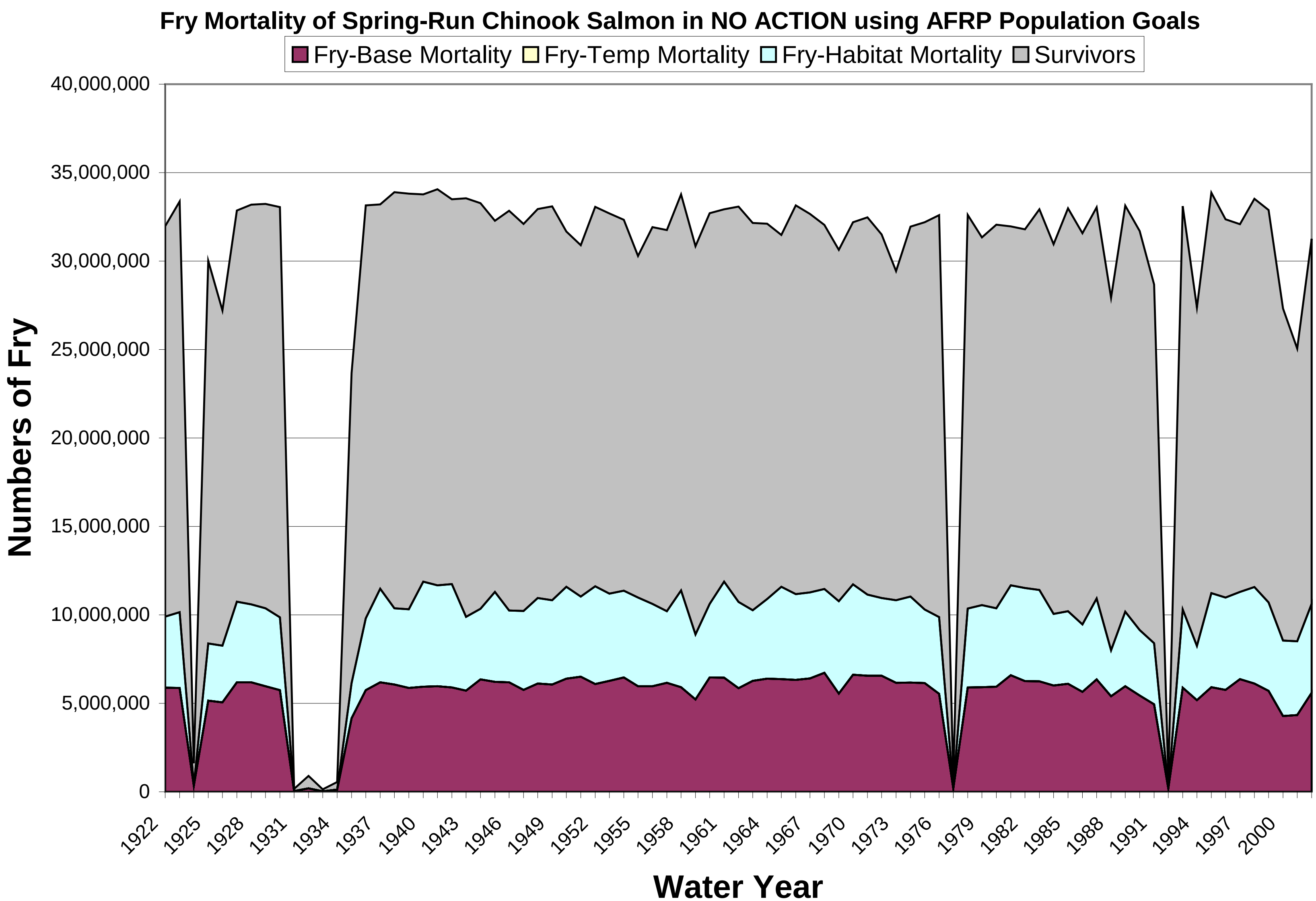

Figure B-24A. Source of mortality of spring-run Chinook salmon fry in NO ACTION based on the AFRP population goals.

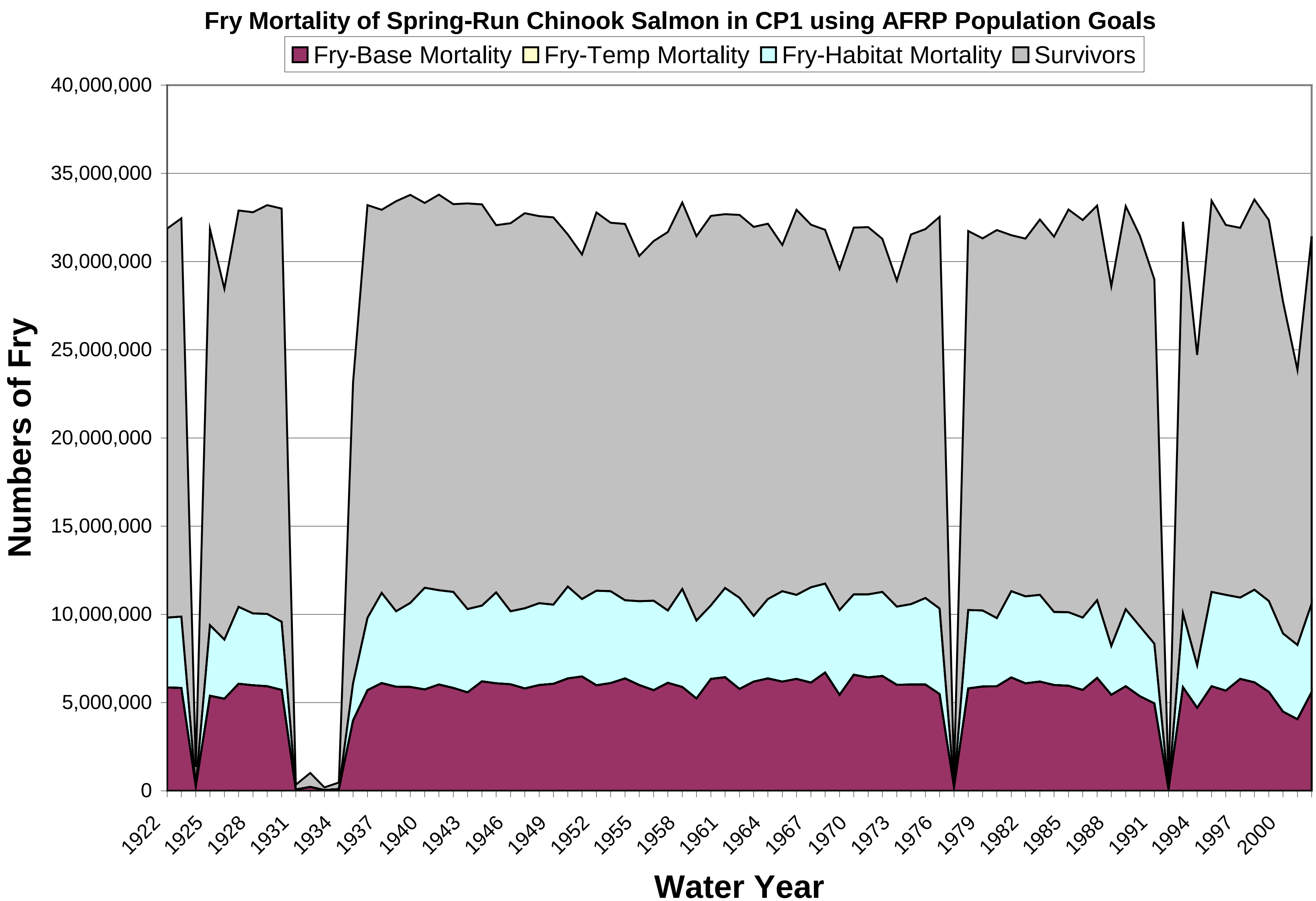

Figure B-24B. Source of mortality of spring-run Chinook salmon fry in CP1 based on the AFRP population goals.

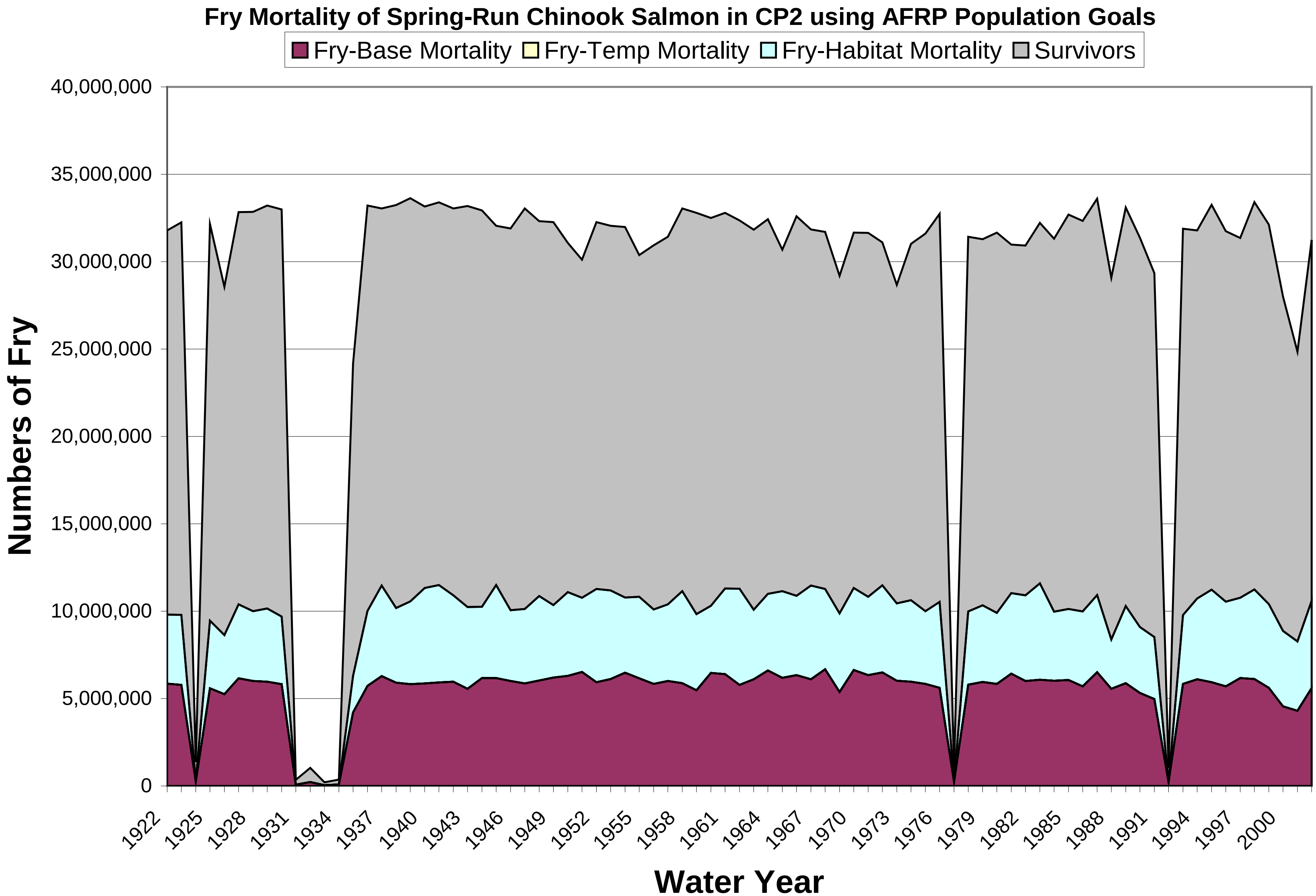

Figure B-24C. Source of mortality of spring-run Chinook salmon fry in CP2 based on the AFRP population goals.

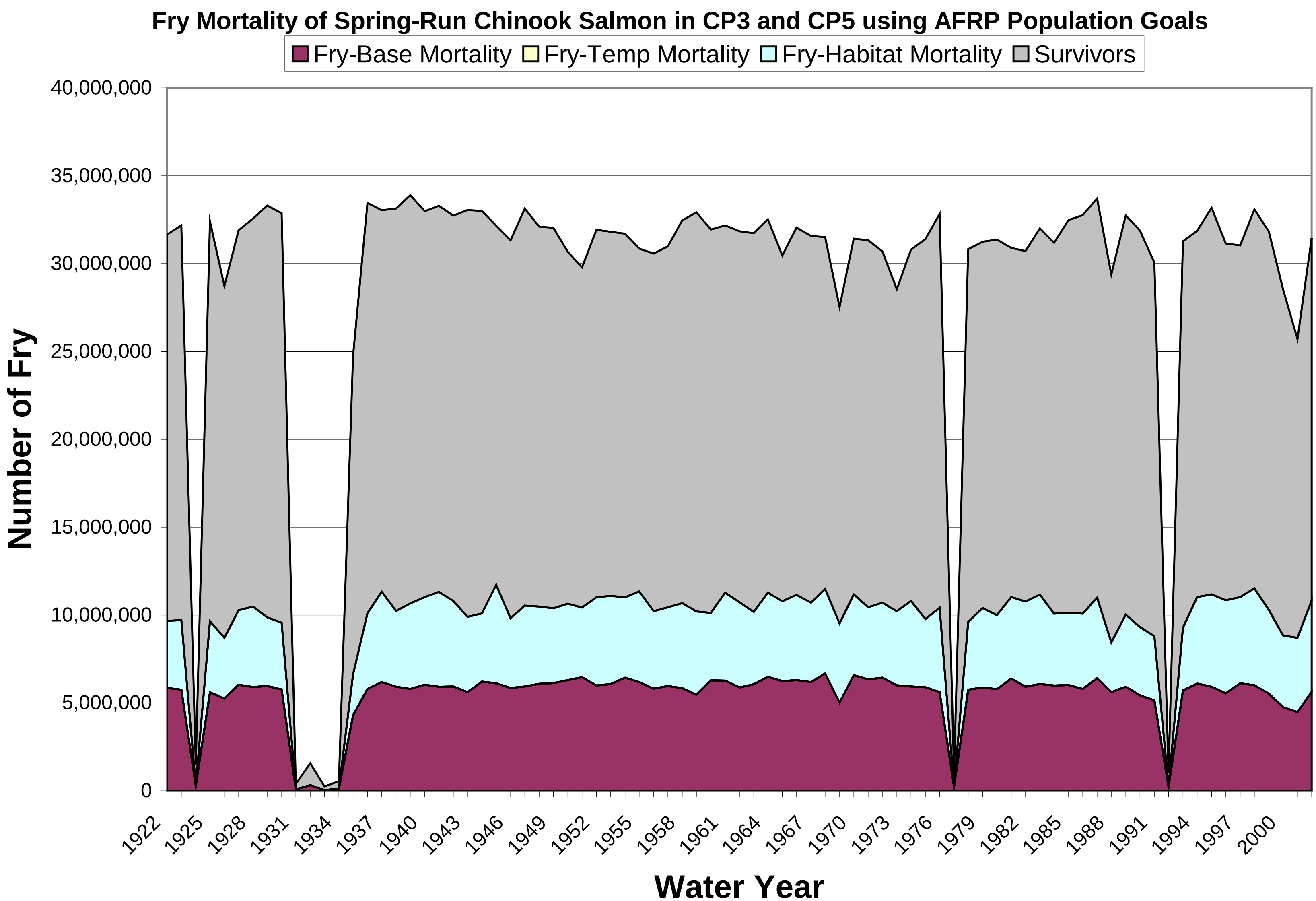

Figure B-24D. Source of mortality of spring-run Chinook salmon fry in CP3 and CP5 based on the AFRP population goals.

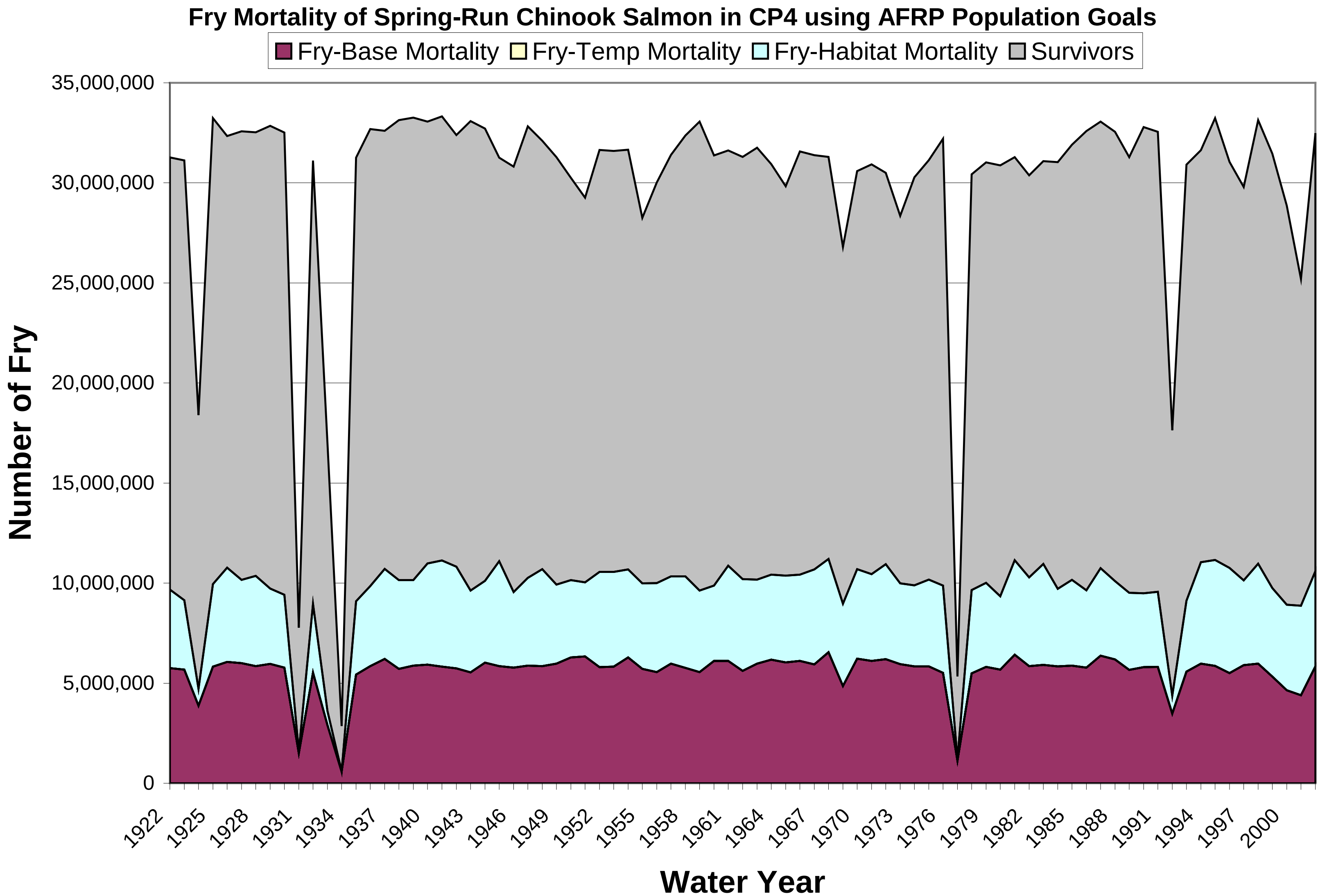

Figure B-24E. Source of mortality of spring-run Chinook salmon fry in CP4 based on the AFRP population goals.

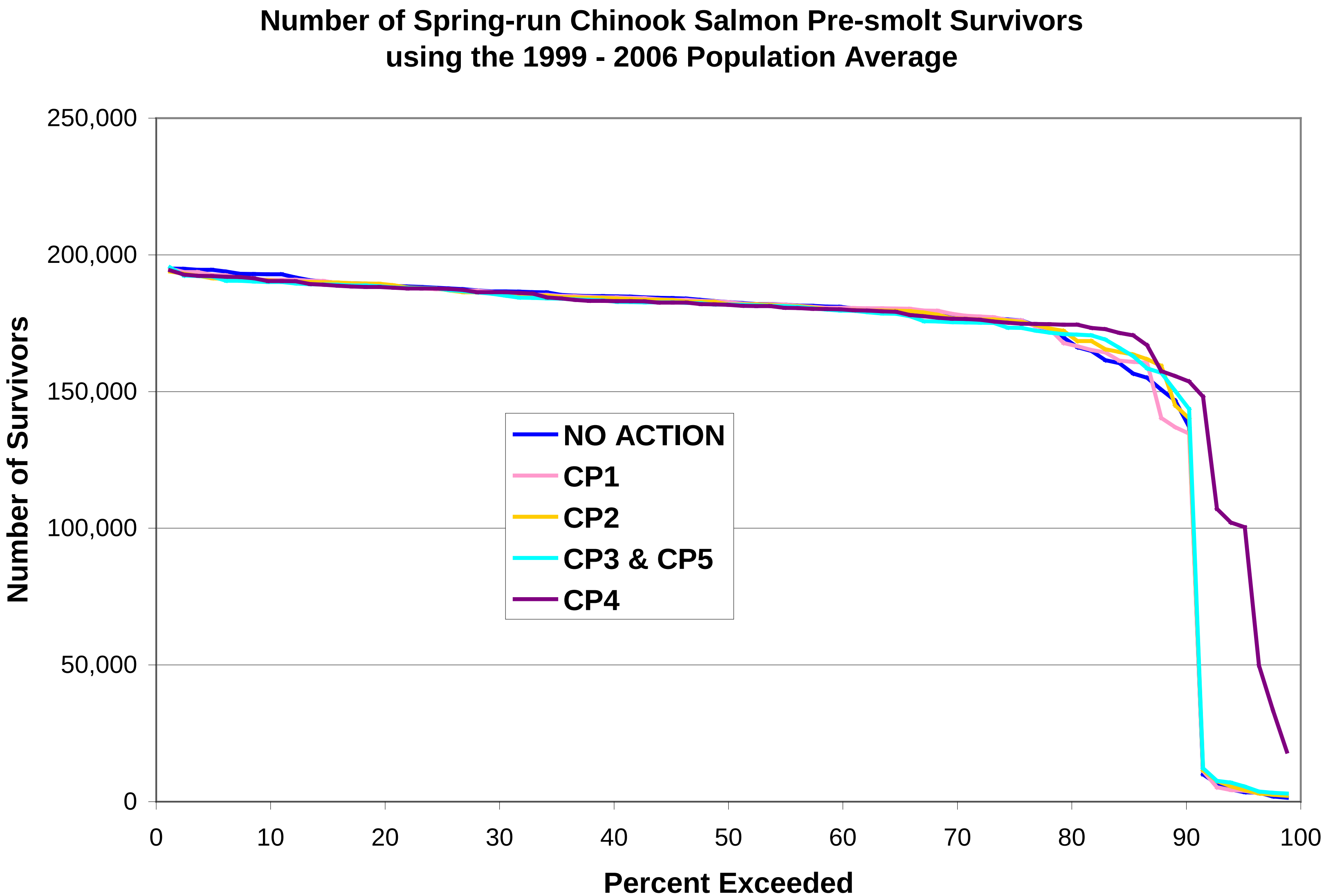

Figure B-25A. Frequency distribution of the number of spring-run Chinook salmon pre-smolt survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

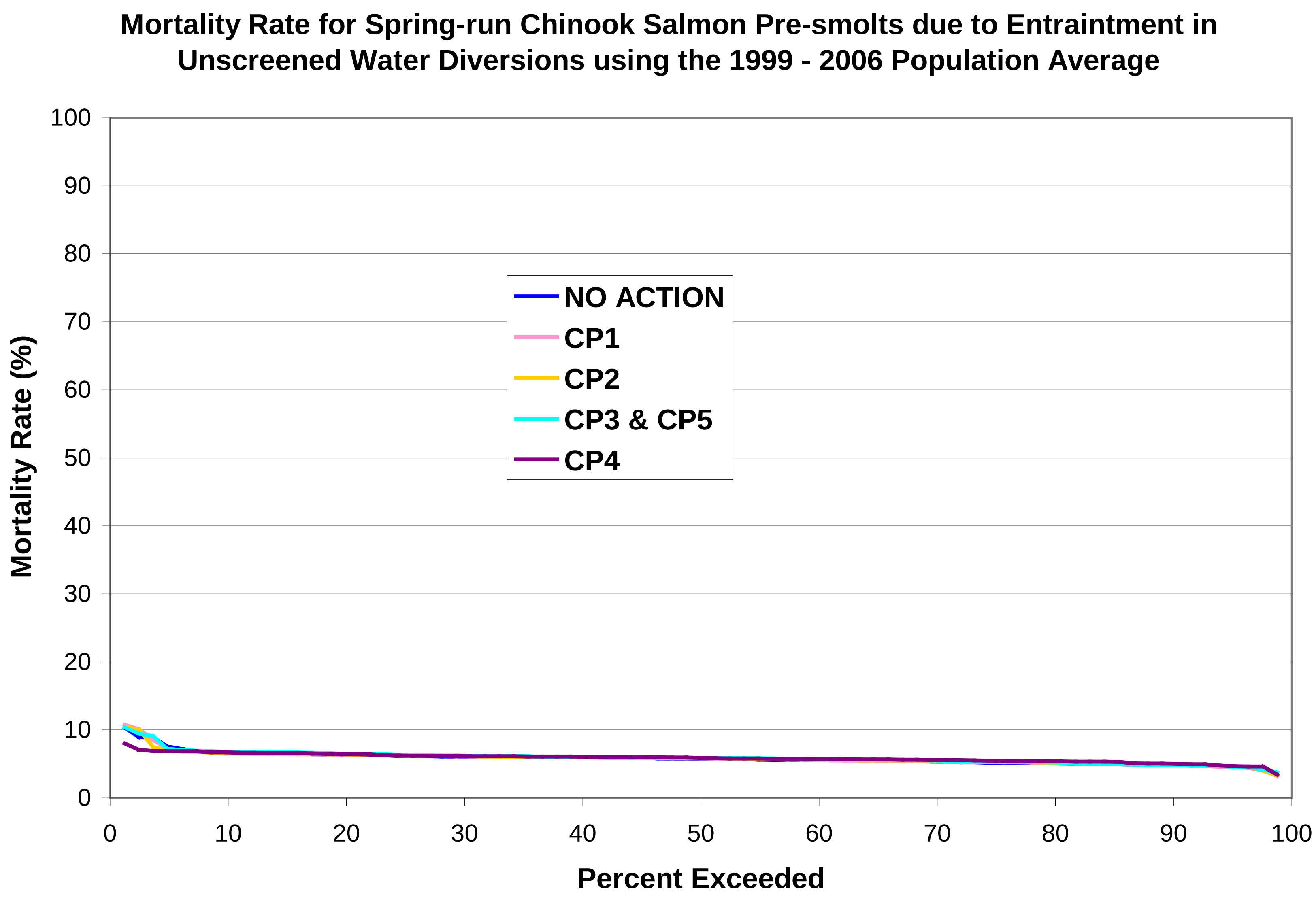

Figure B-25B. Frequency distribution of the mortality rate of spring-run Chinook salmon pre-smolts due to entrainment in unscreened water diversions during the 1921-2003 simulation period based on the 1999-2006 population average.

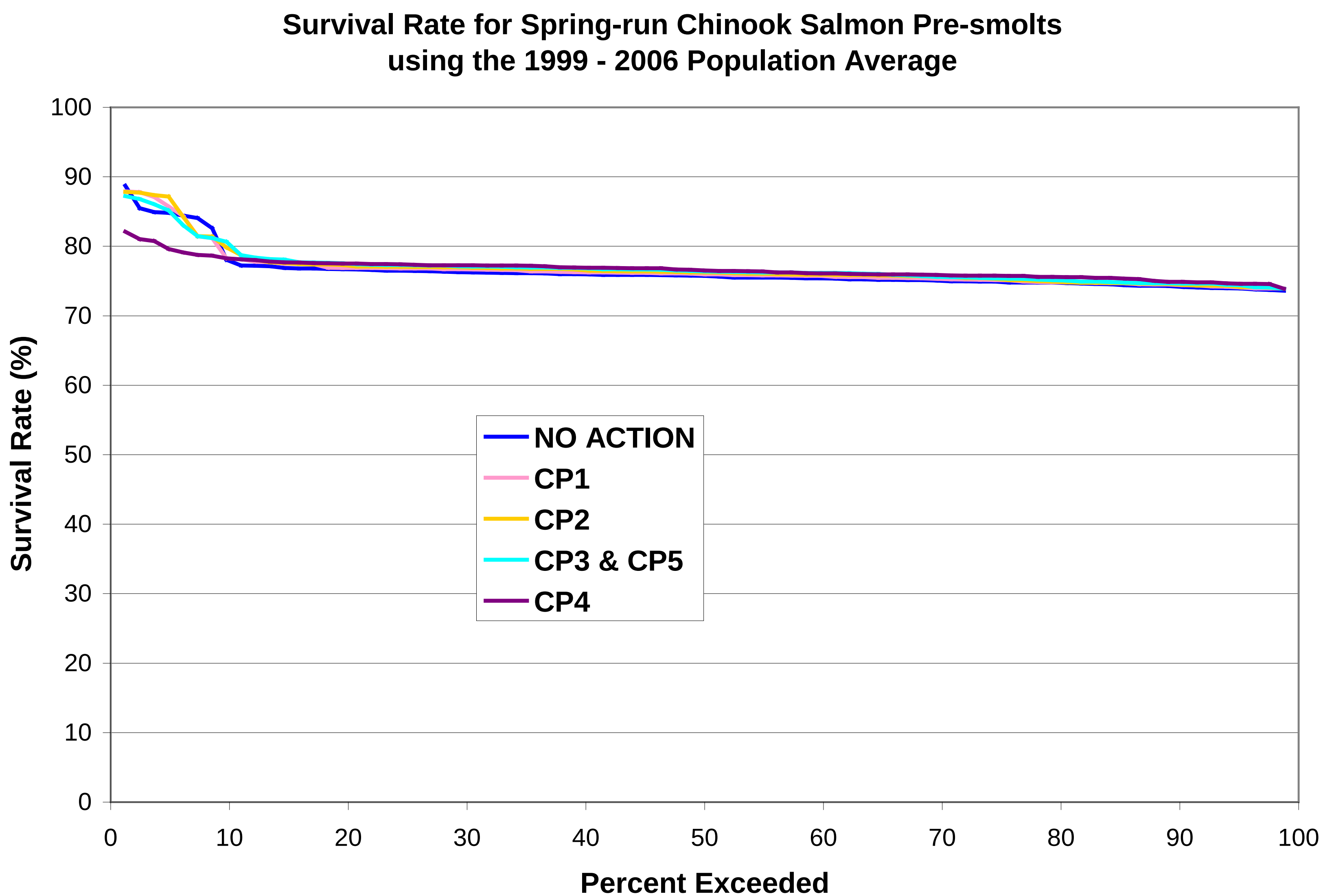

Figure B-25C. Frequency distribution of the survival rate of spring-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the 1999-2006 population average.

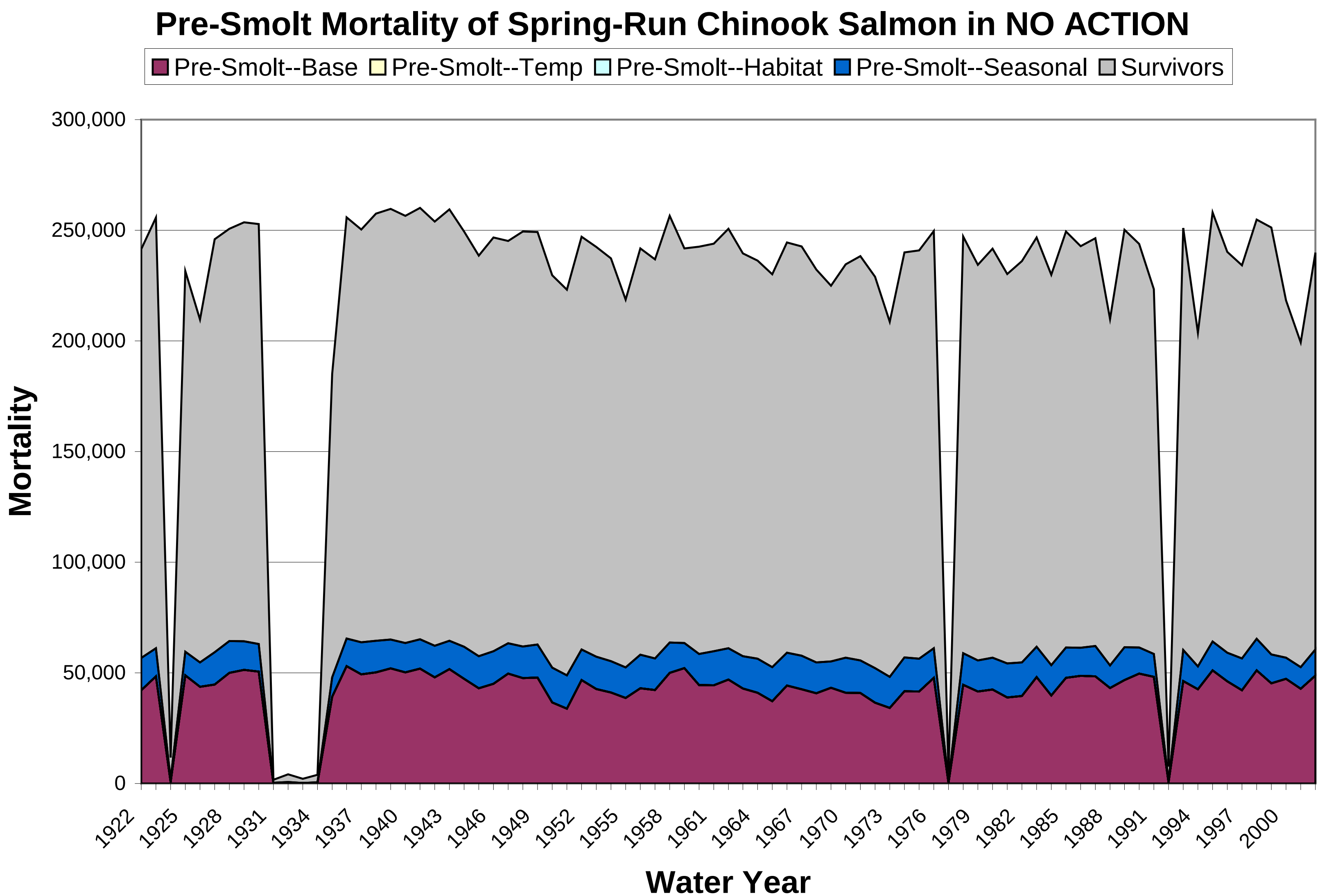

Figure B-26A. Source of mortality of spring-run Chinook salmon pre-smolts in NO ACTION based on the 1999-2006 population average.

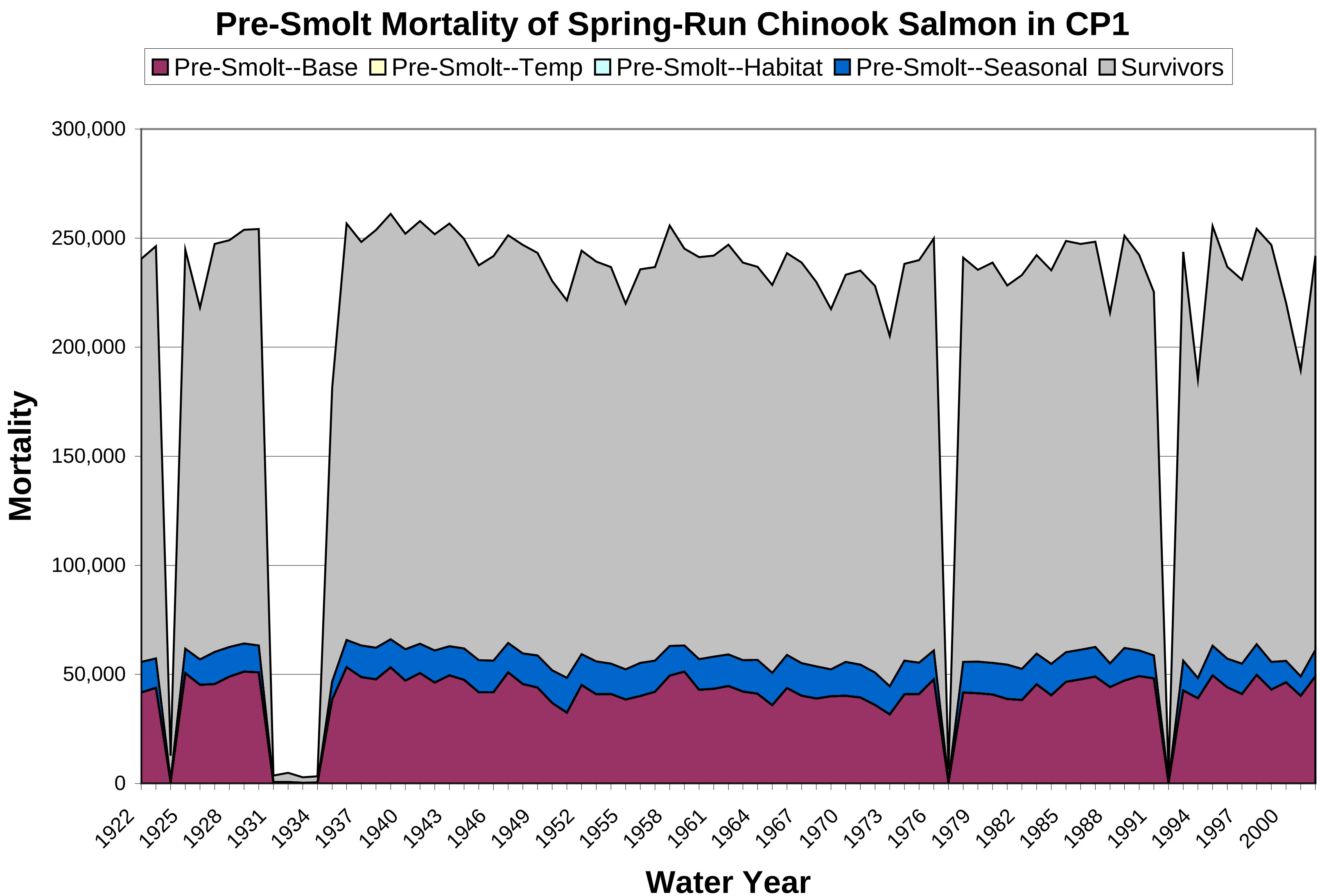

Figure B-26B. Source of mortality of spring-run Chinook salmon pre-smolts in CP1 based on the 1999-2006 population average.

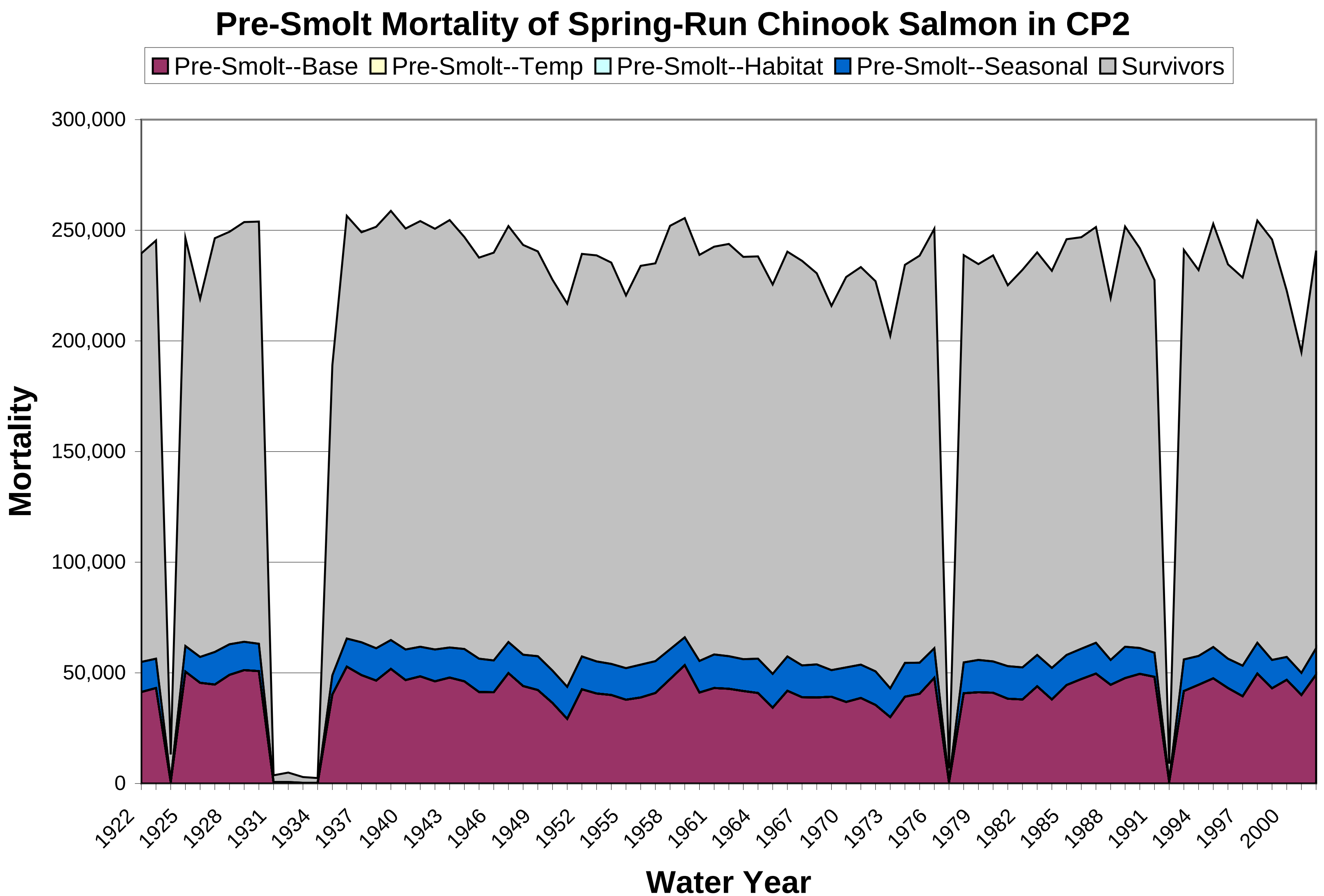

Figure B-26C. Source of mortality of spring-run Chinook salmon pre-smolts in CP2 based on the 1999-2006 population average.

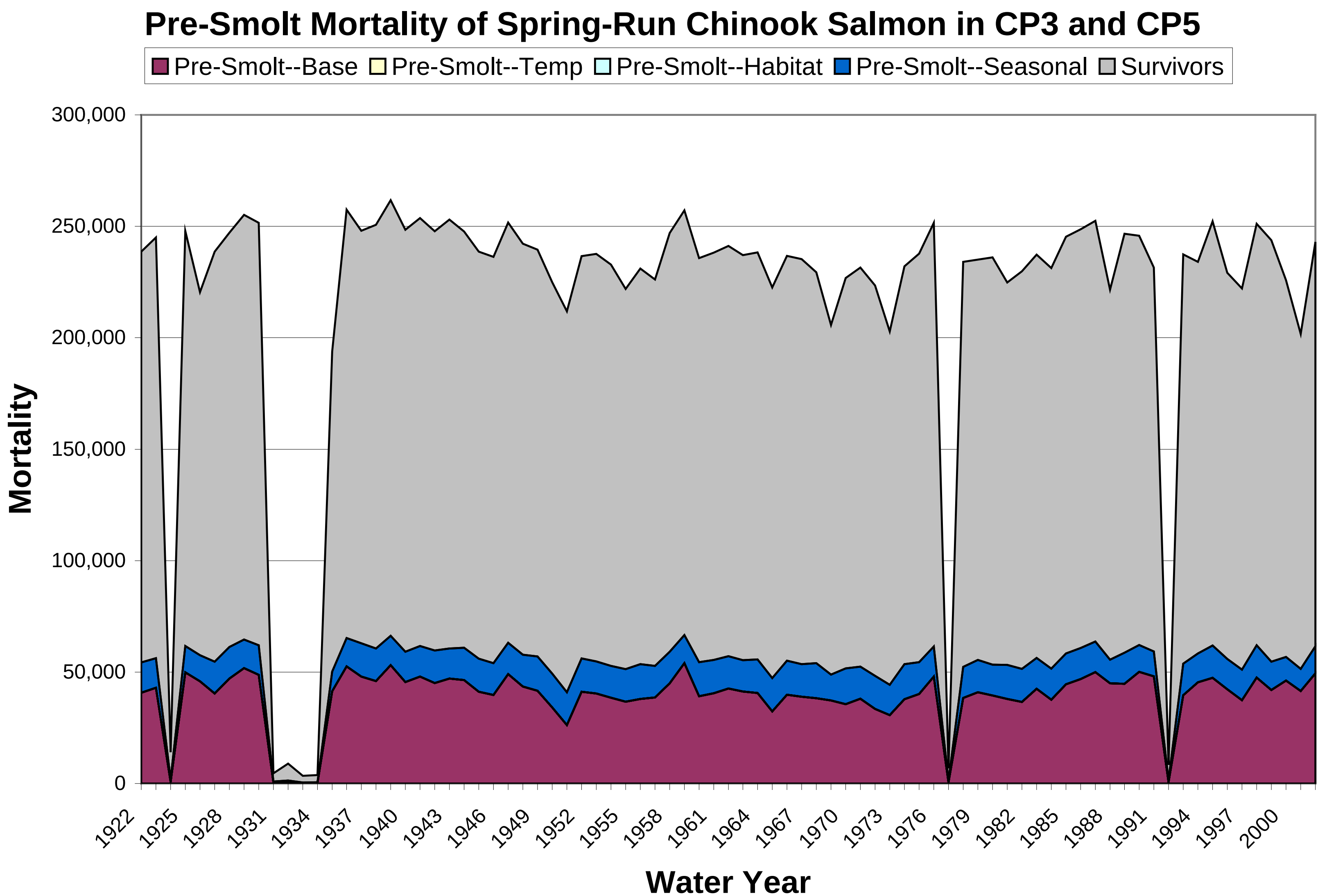

Figure B-26D. Source of mortality of spring-run Chinook salmon pre-smolts in CP3 and CP5 based on the 1999-2006 population average.

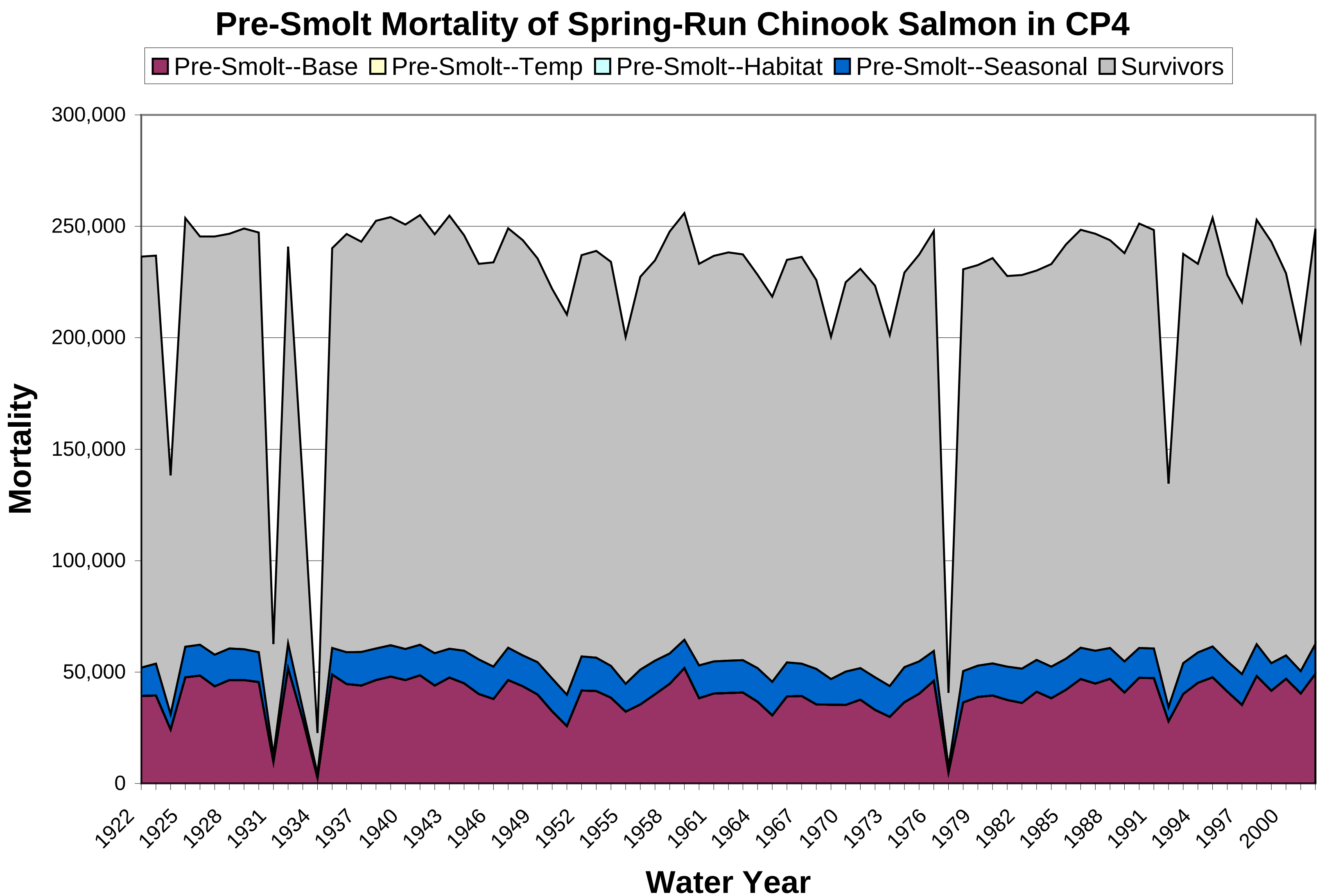

Figure B-26E. Source of mortality of spring-run Chinook salmon pre-smolts in CP4 based on the 1999-2006 population average.

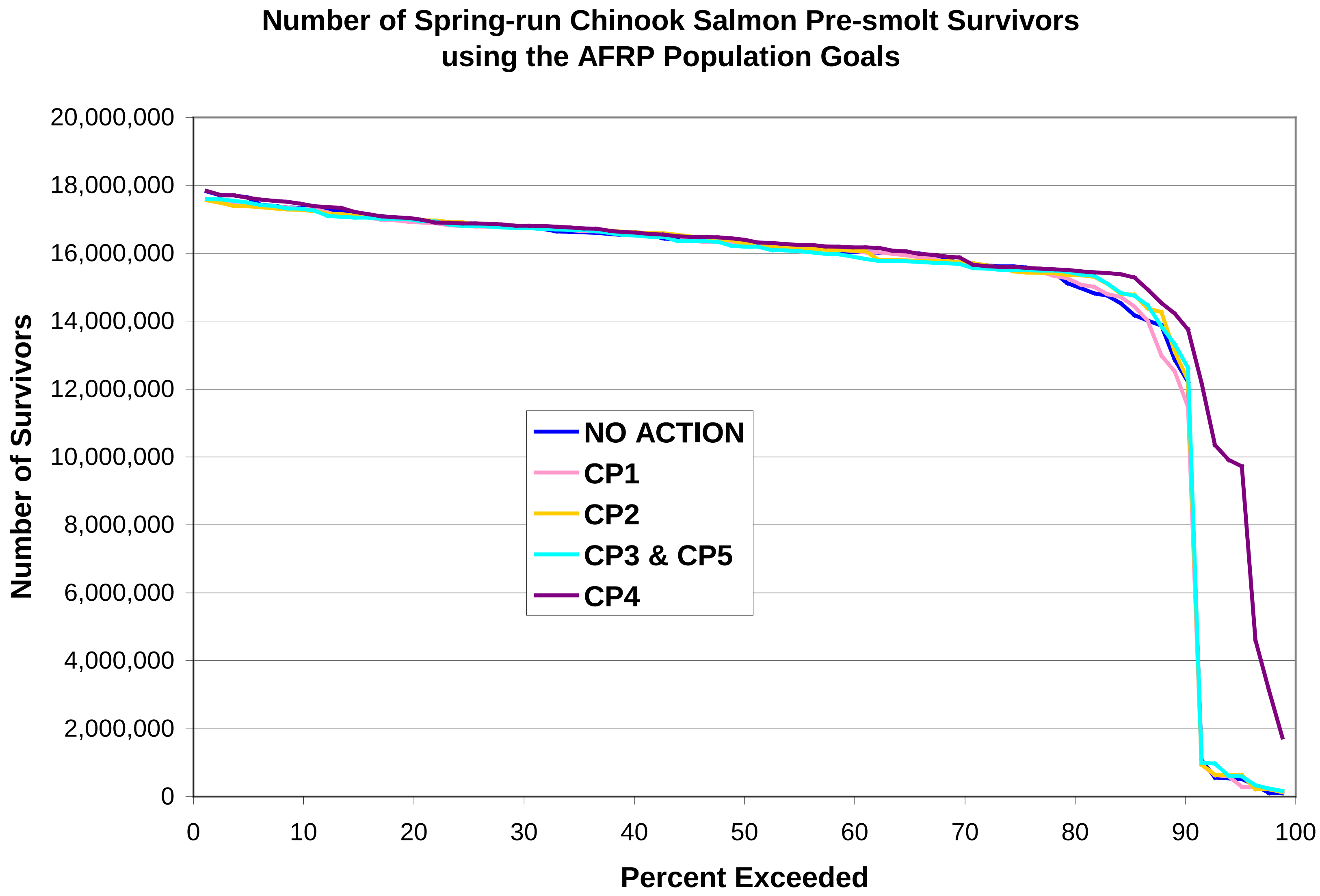

Figure B-27A. Frequency distribution of the number of spring-run Chinook salmon pre-smolt survivors during the 1921-2003 simulation period based on the AFRP population goals.

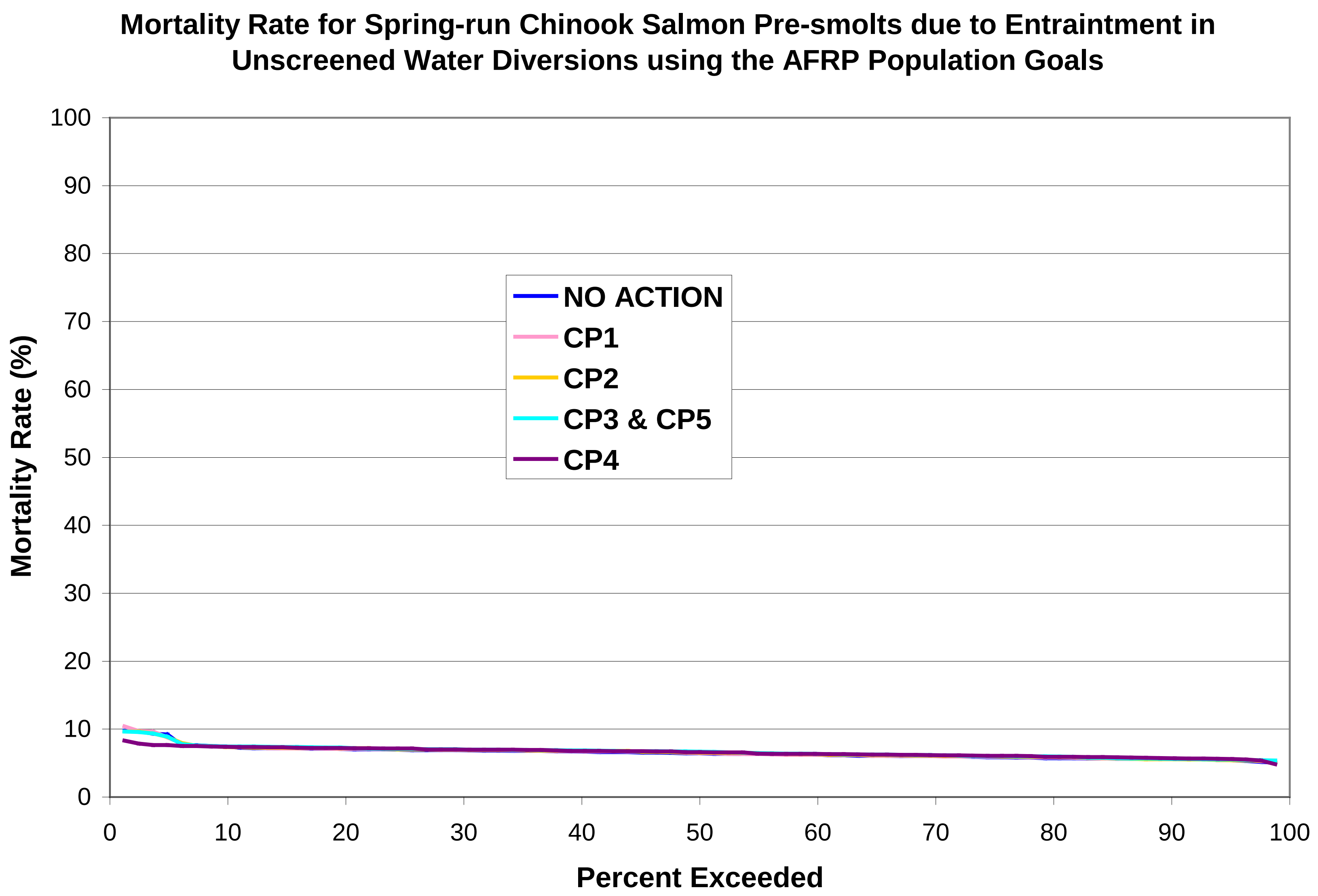

Figure B-27B. Frequency distribution of the mortality rate of spring-run Chinook salmon pre-smolts due to entrainment in unscreened water diversions during the 1921-2003 simulation period based on the AFRP population goals.

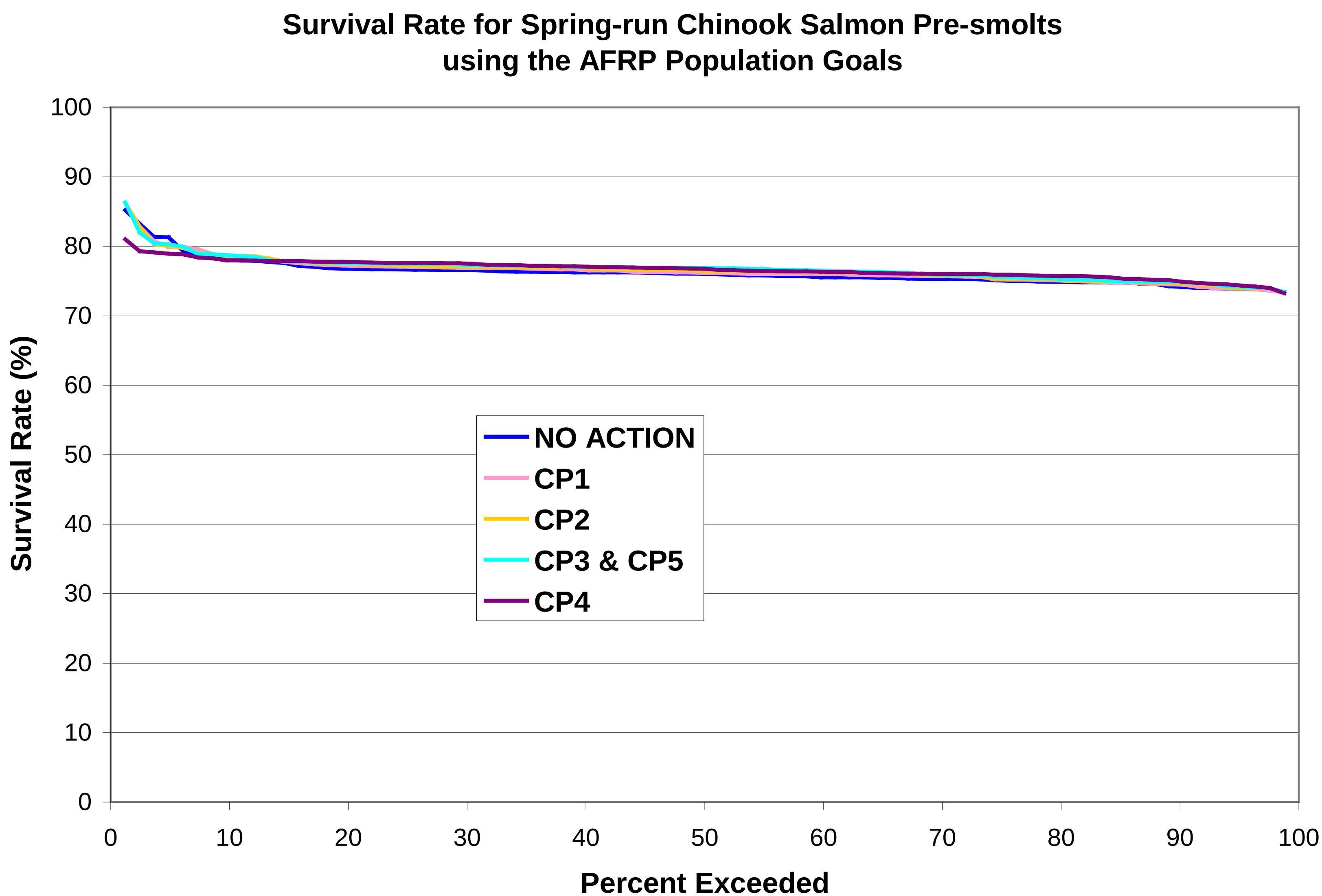

Figure B-27C. Frequency distribution of the survival rate of spring-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the AFRP population goals.

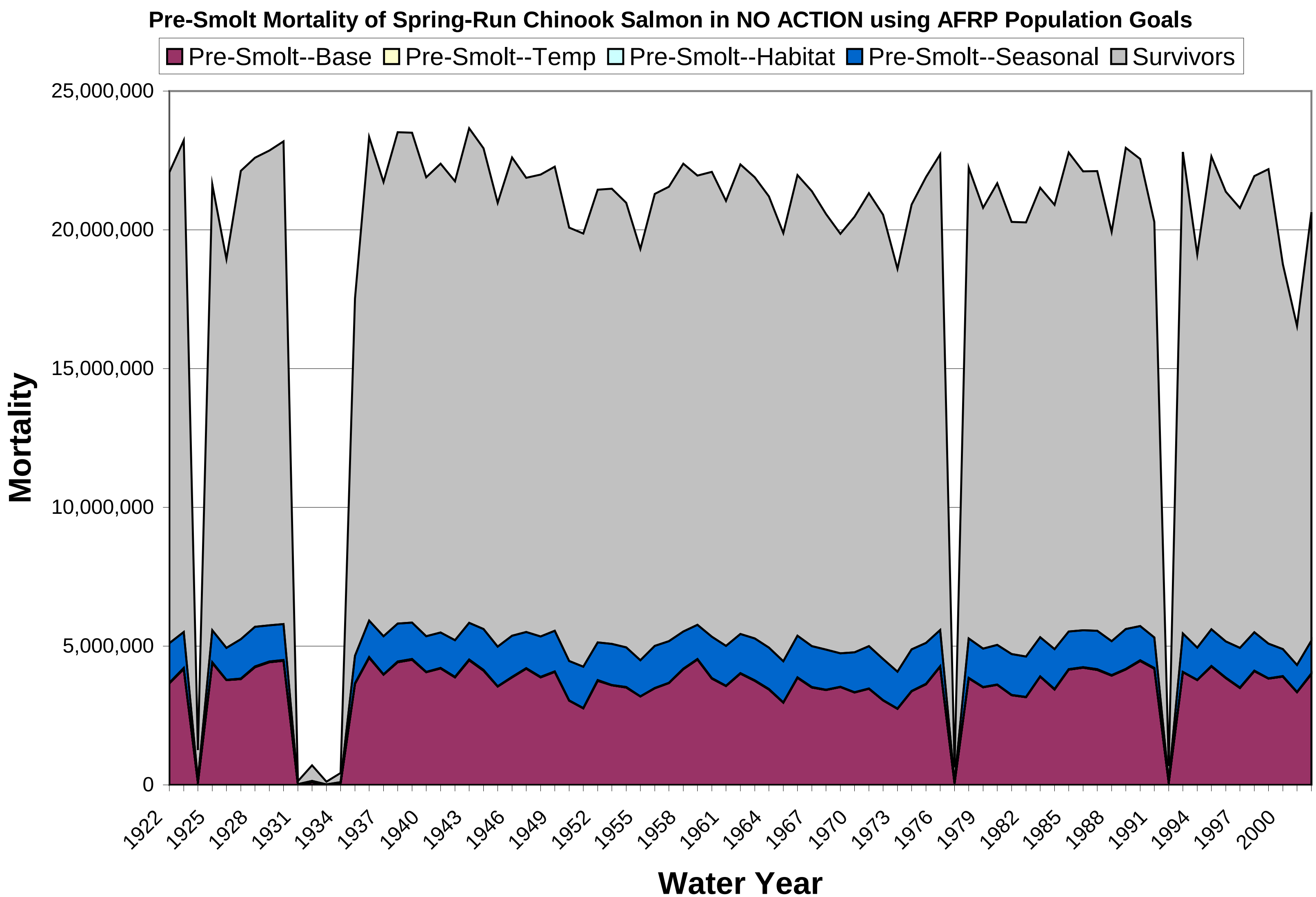

Figure B-28A. Source of mortality of spring-run Chinook salmon pre-smolts in NO ACTION based on the AFRP population goals.

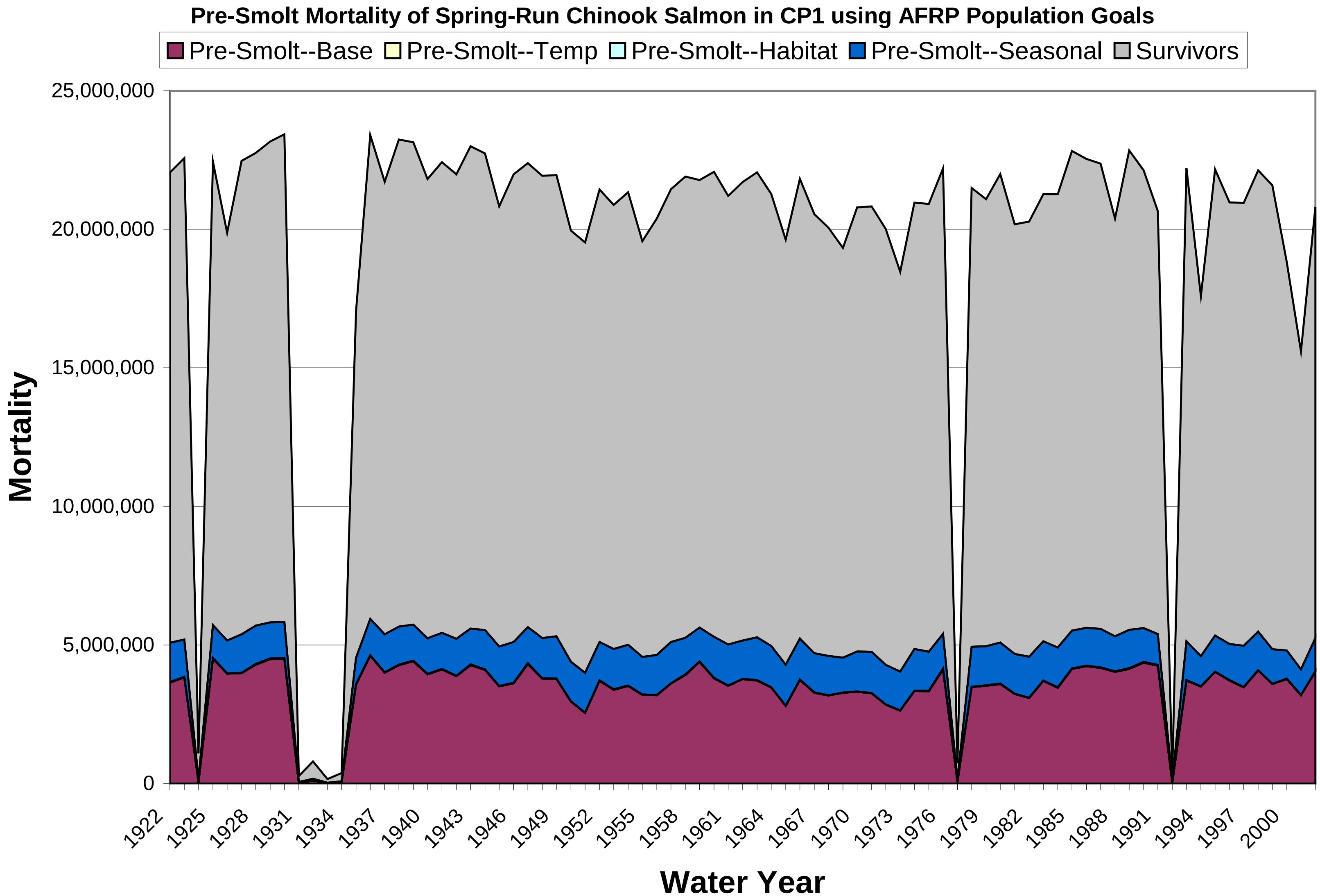

Figure B-28B. Source of mortality of spring-run Chinook salmon pre-smolts in CP1 based on the AFRP population goals.

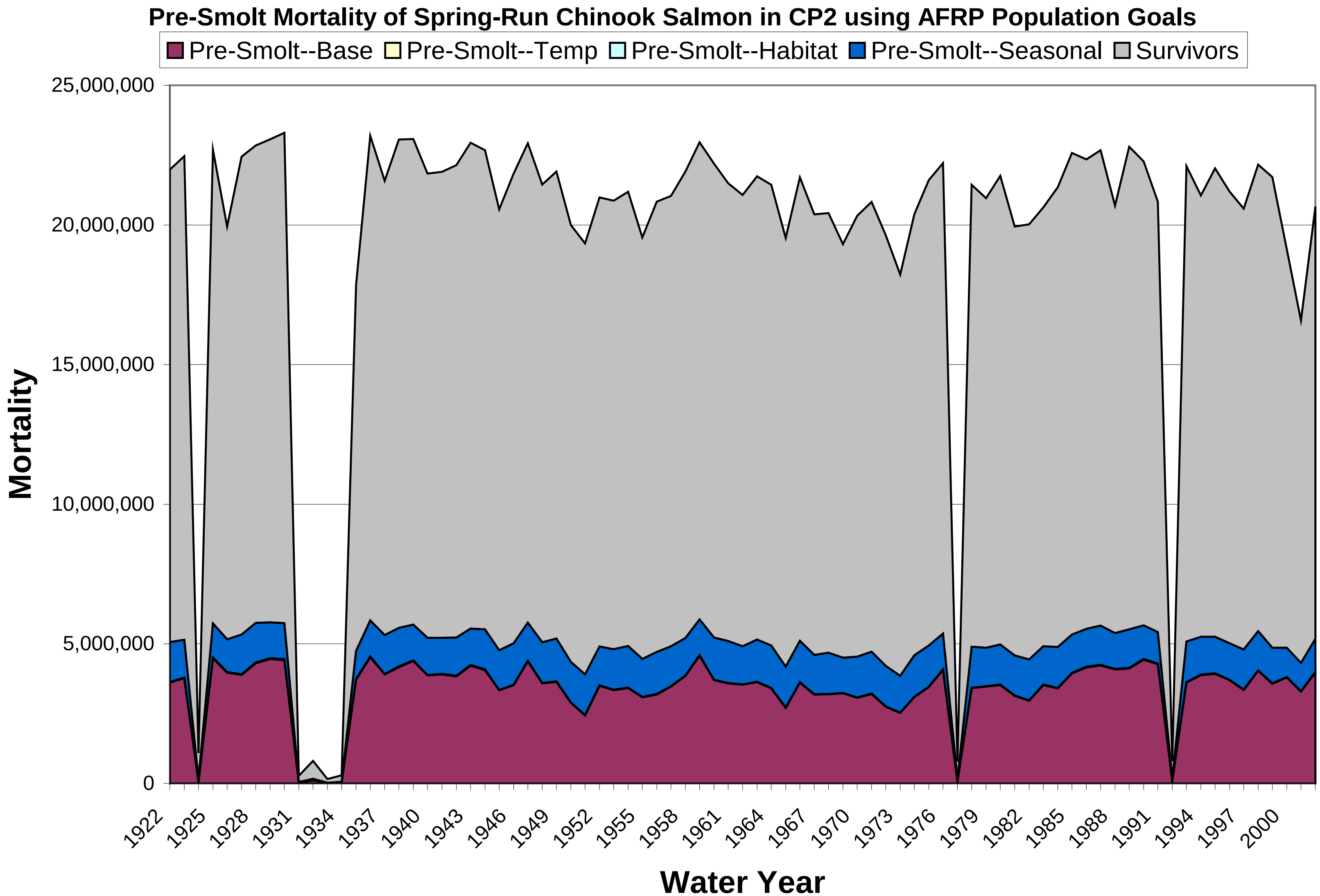

Figure B-28C. Source of mortality of spring-run Chinook salmon pre-smolts in CP2 based on the AFRP population goals.

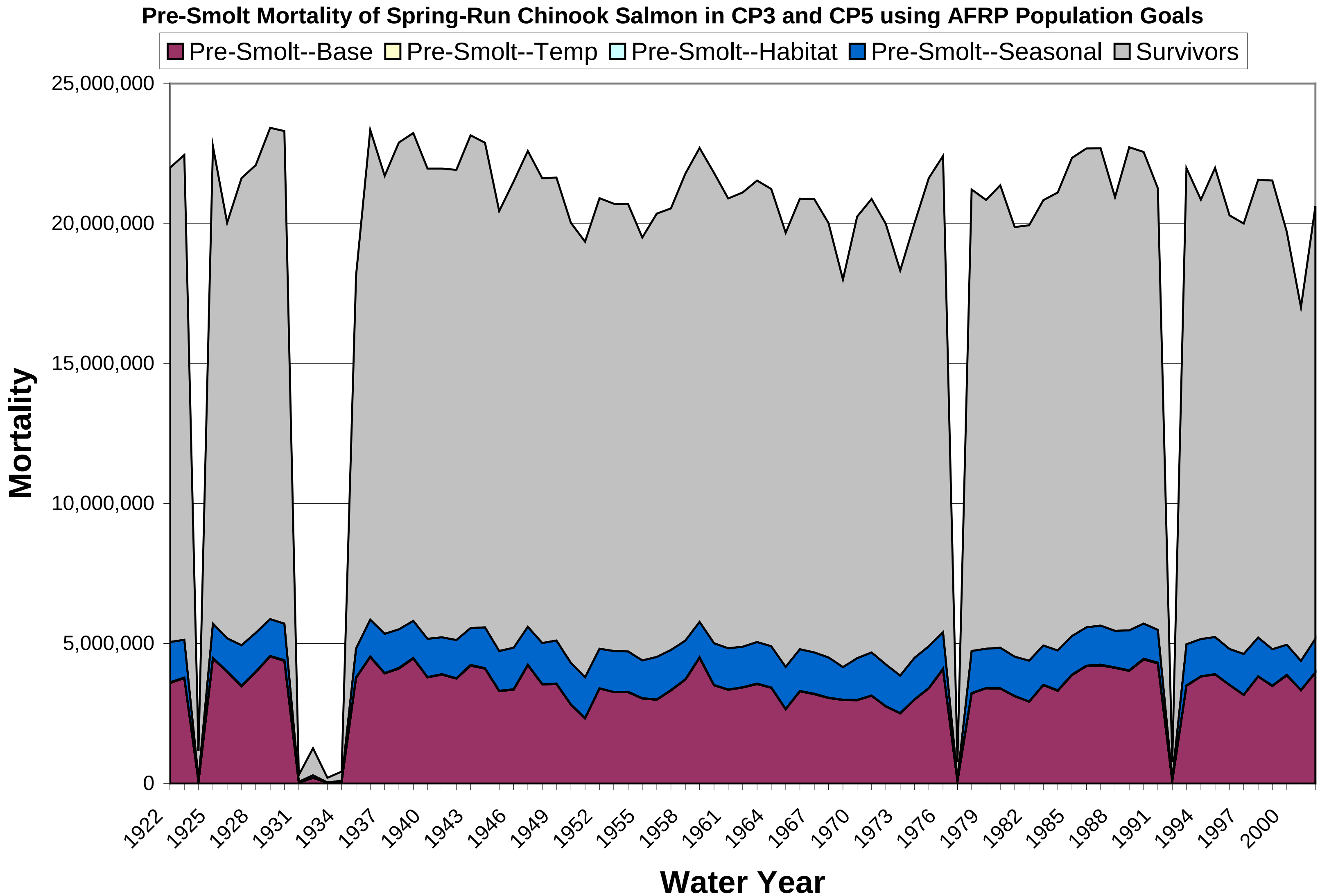

Figure B-28D. Source of mortality of spring-run Chinook salmon pre-smolts in CP3 and CP5 based on the AFRP population goals.

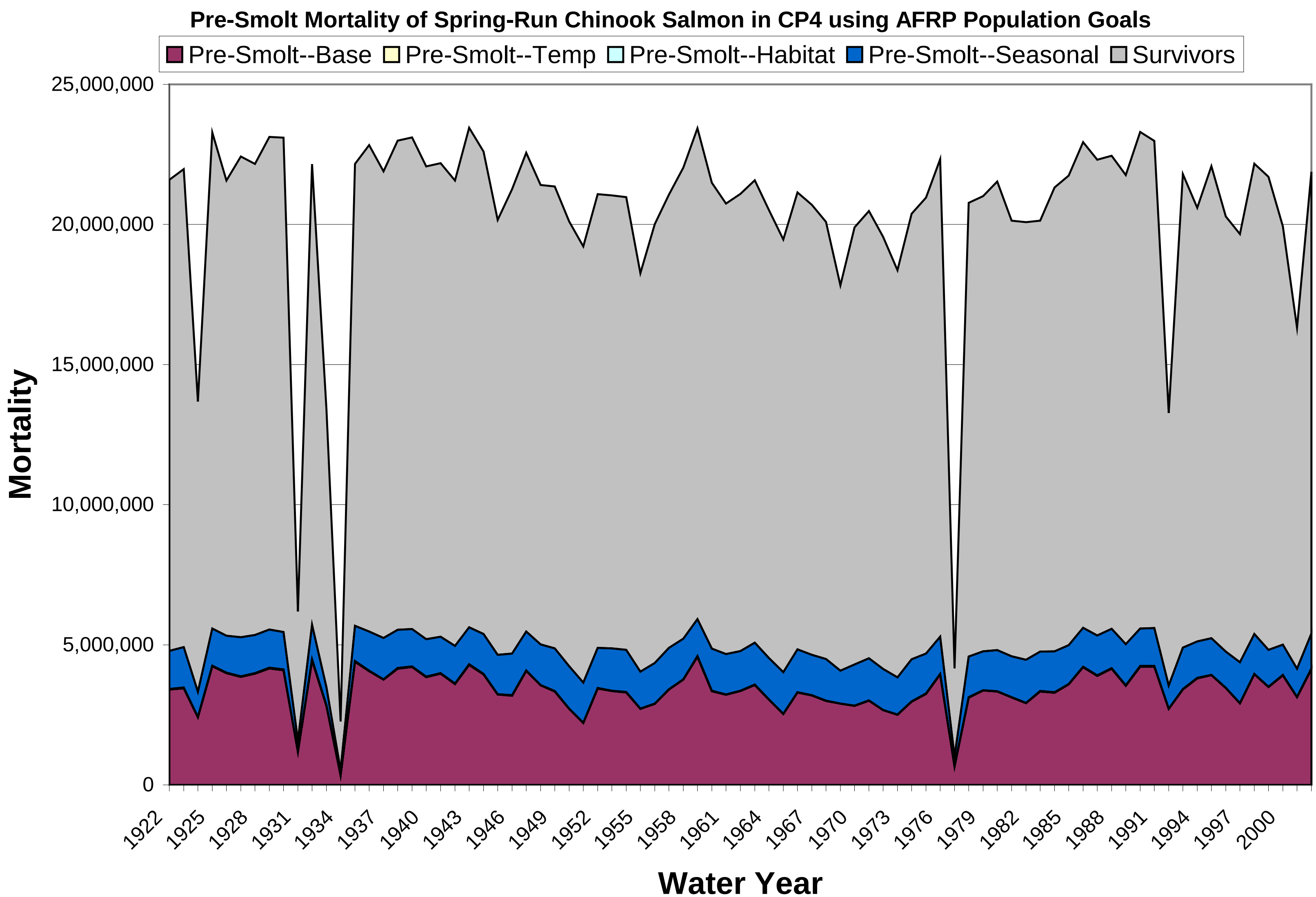

Figure B-28E. Source of mortality of spring-run Chinook salmon pre-smolts in CP4 based on the AFRP population goals.

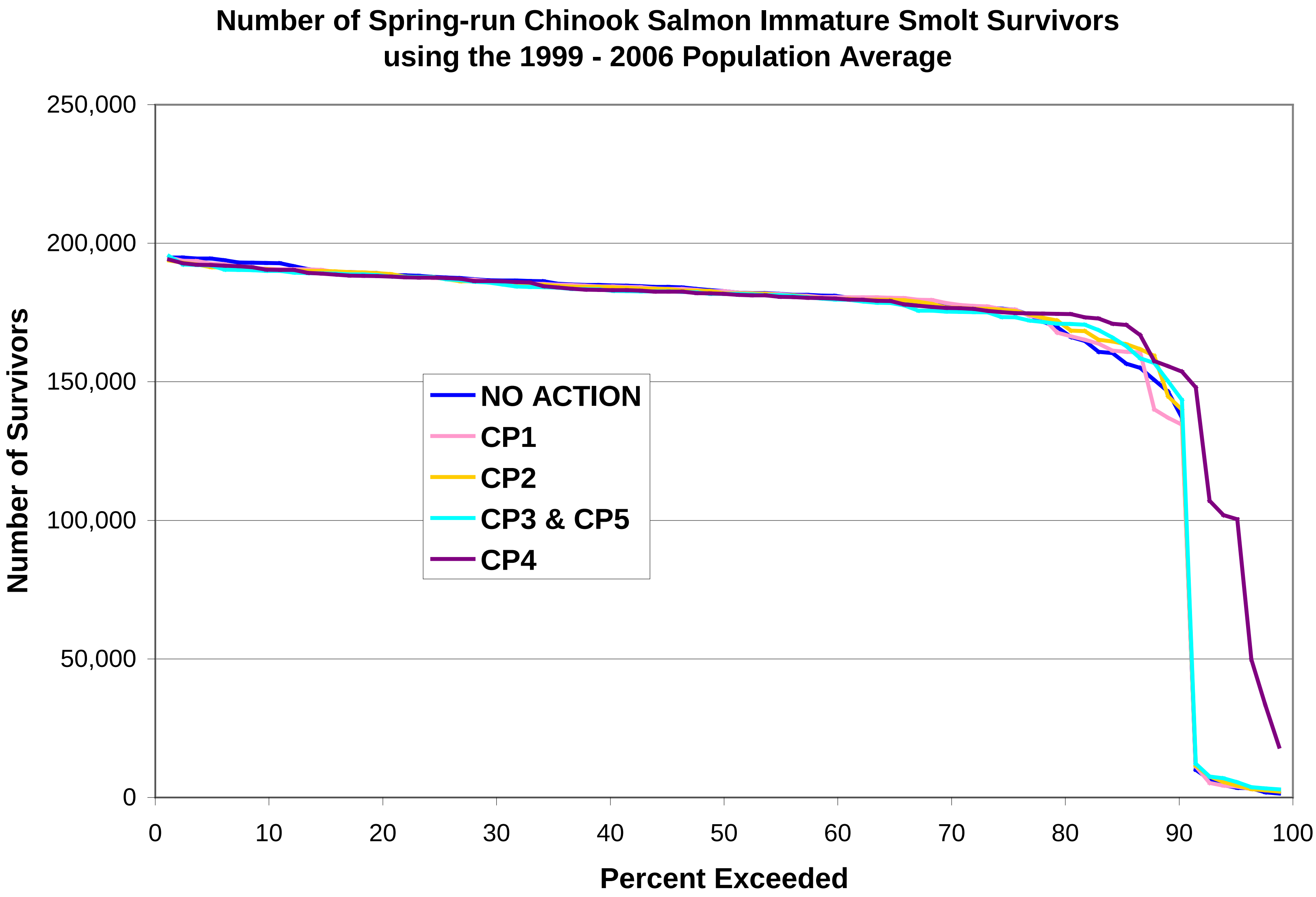

Figure B-29A. Frequency distribution of the number of spring-run Chinook salmon immature smolt survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

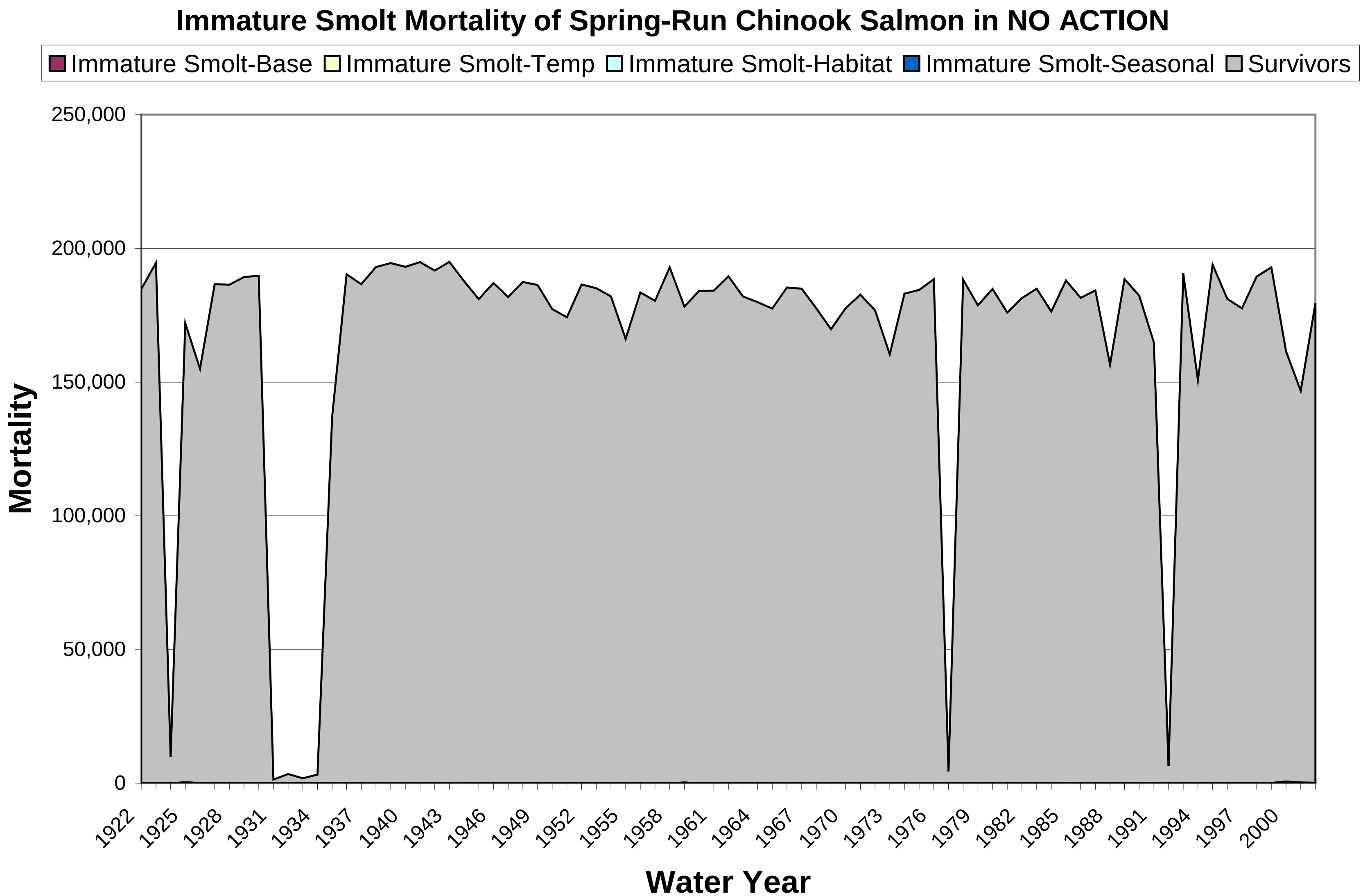

Figure B-30A. Source of mortality of spring-run Chinook salmon immature smolts in NO ACTION based on the 1999-2006 population average.

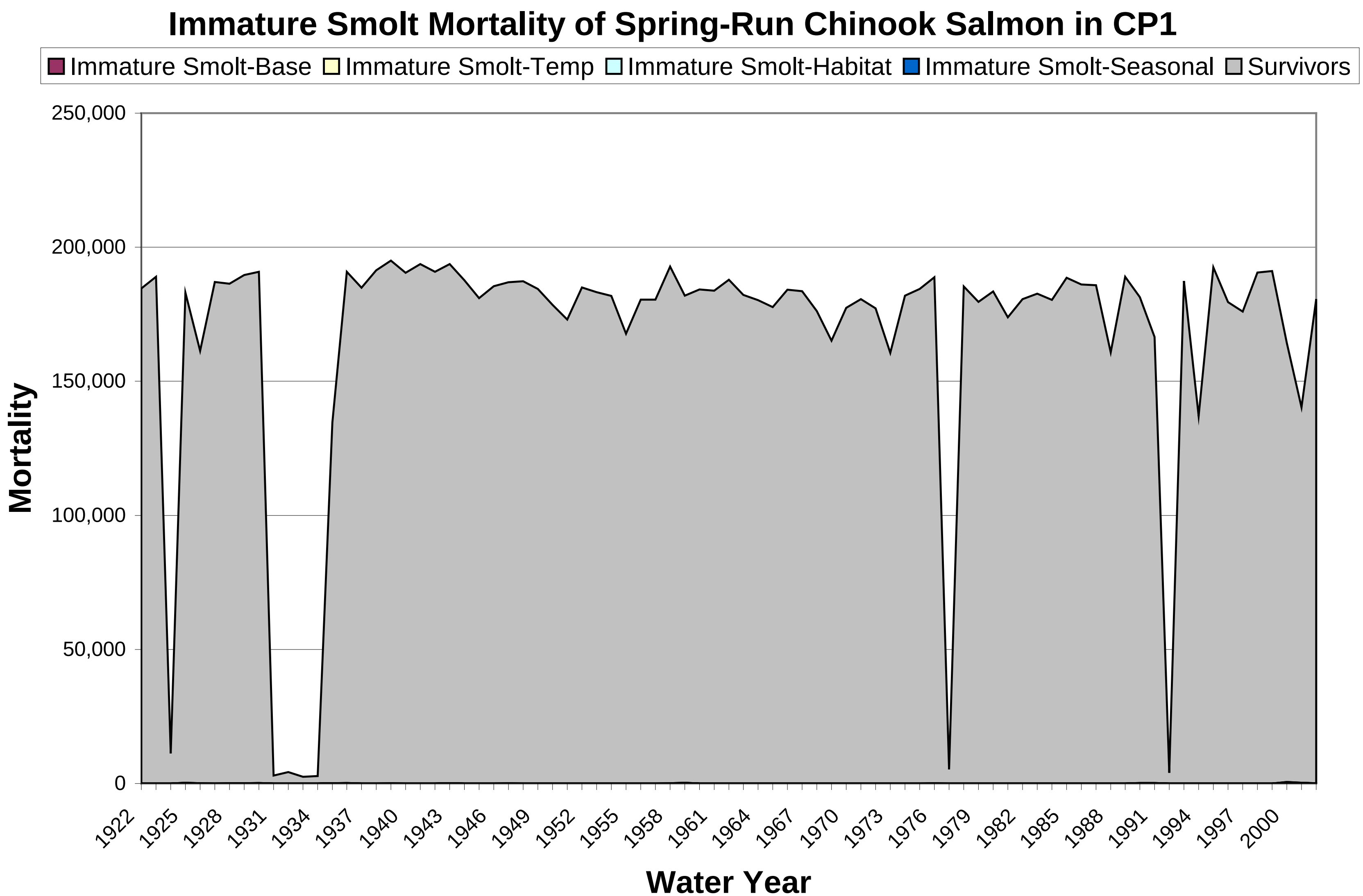

Figure B-30B. Source of mortality of spring-run Chinook salmon immature smolts in CP1 based on the 1999-2006 population average.

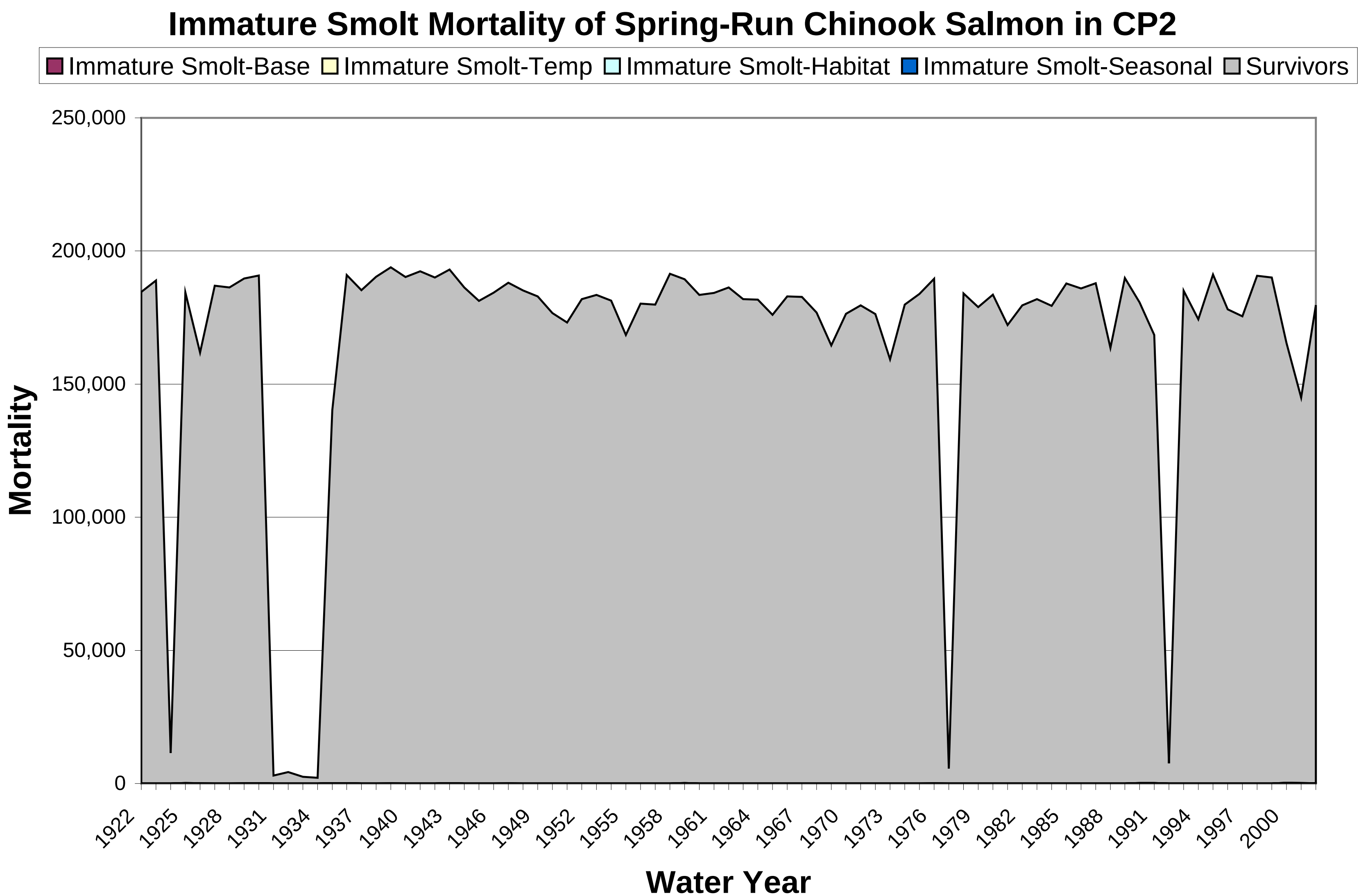

Figure B-30C. Source of mortality of spring-run Chinook salmon immature smolts in CP2 based on the 1999-2006 population average.

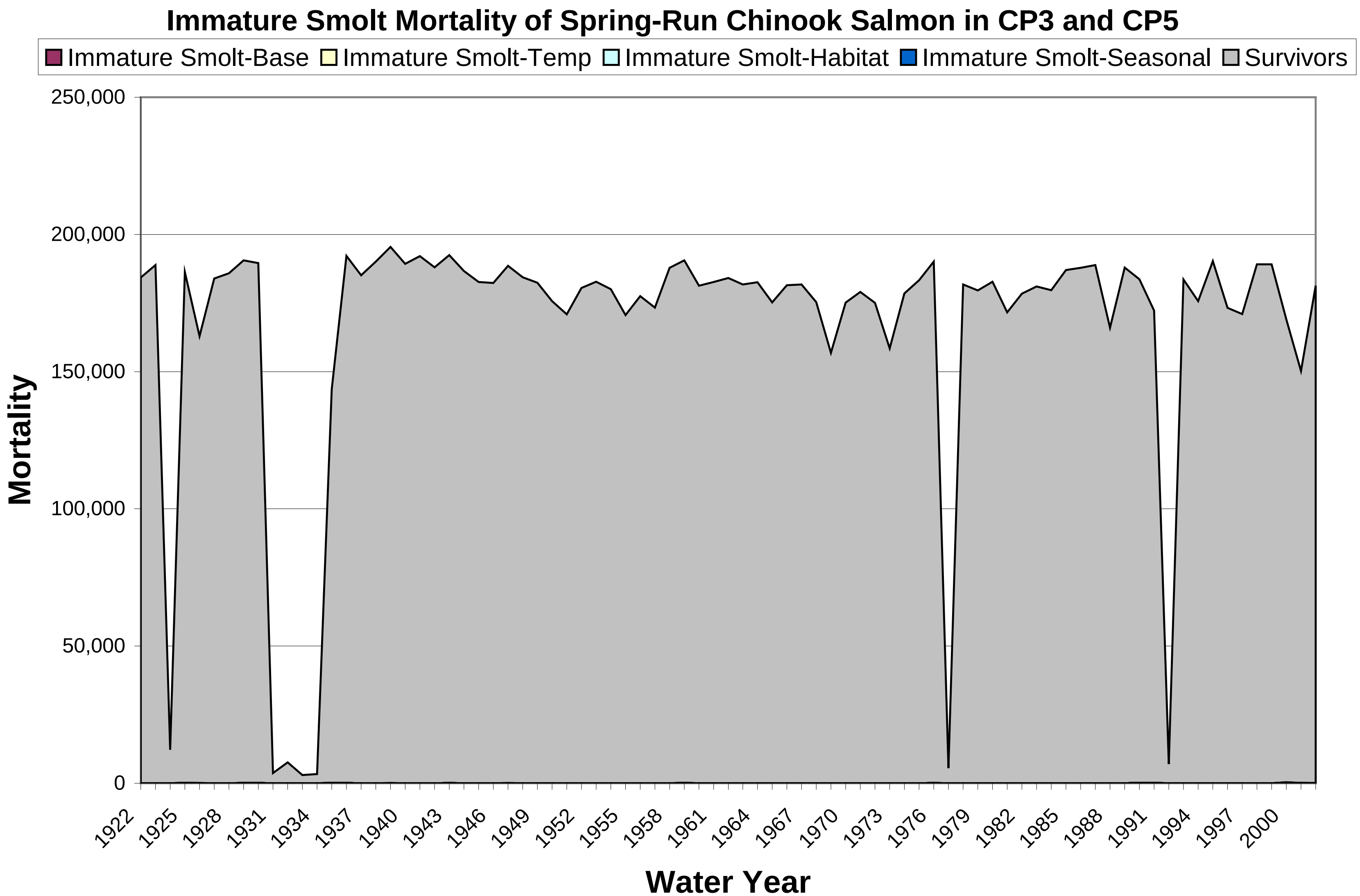

Figure B-30D. Source of mortality of spring-run Chinook salmon immature smolts in CP3 and CP5 based on the 1999-2006 population average.

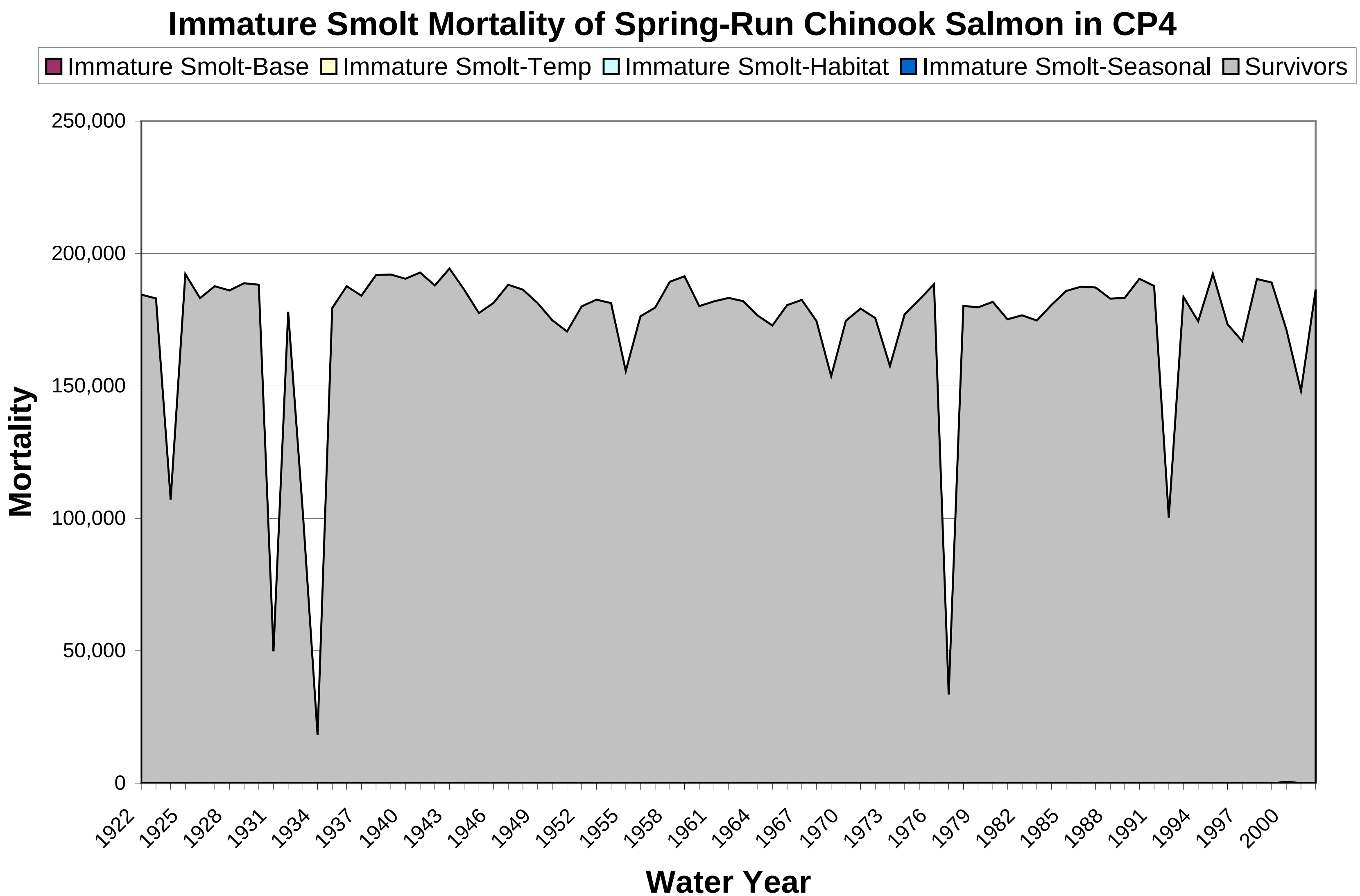

Figure B-30E. Source of mortality of spring-run Chinook salmon immature smolts in CP4 based on the 1999-2006 population average.

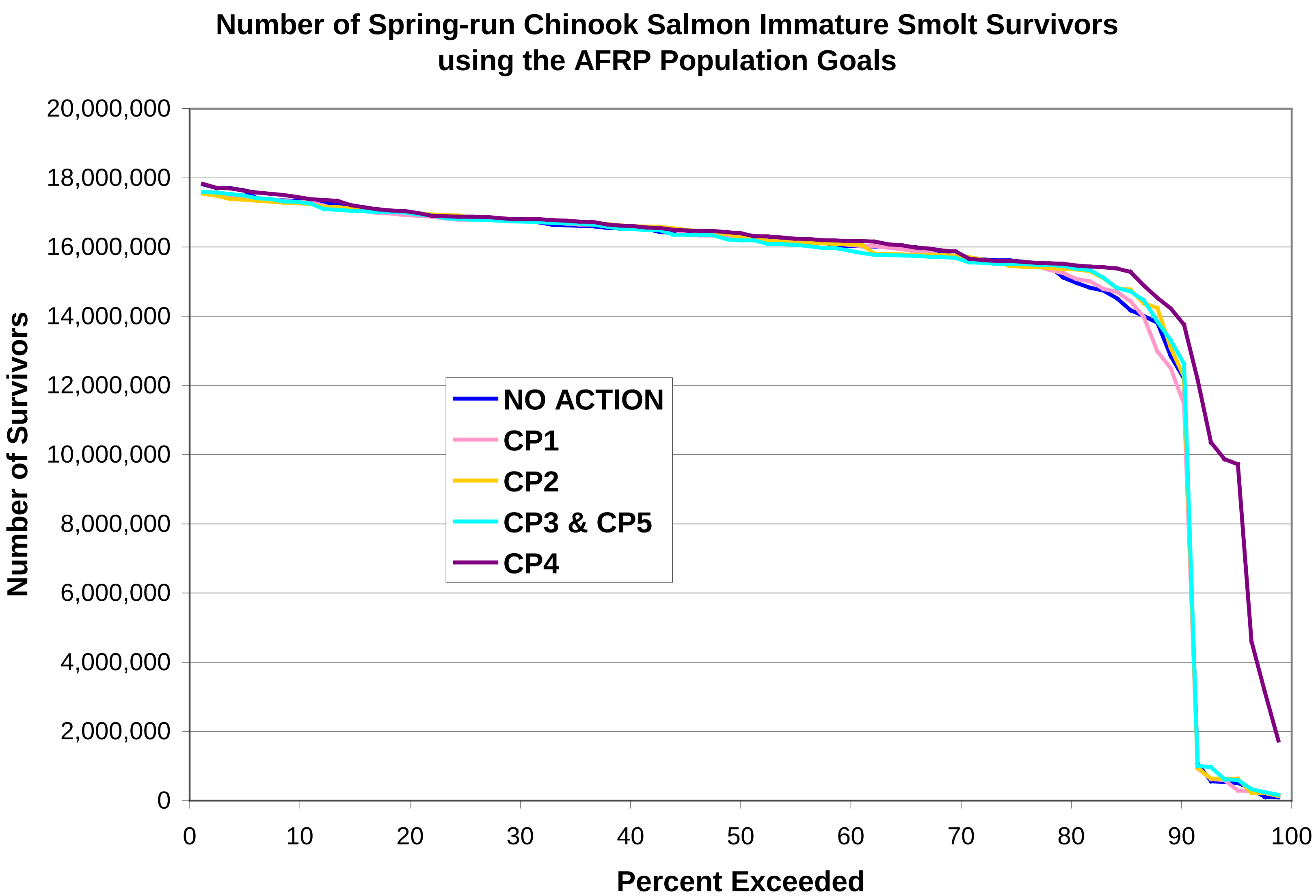

Figure B-31A. Frequency distribution of the number of spring-run Chinook salmon immature smolt survivors during the 1921-2003 simulation period based on the AFRP population goals.

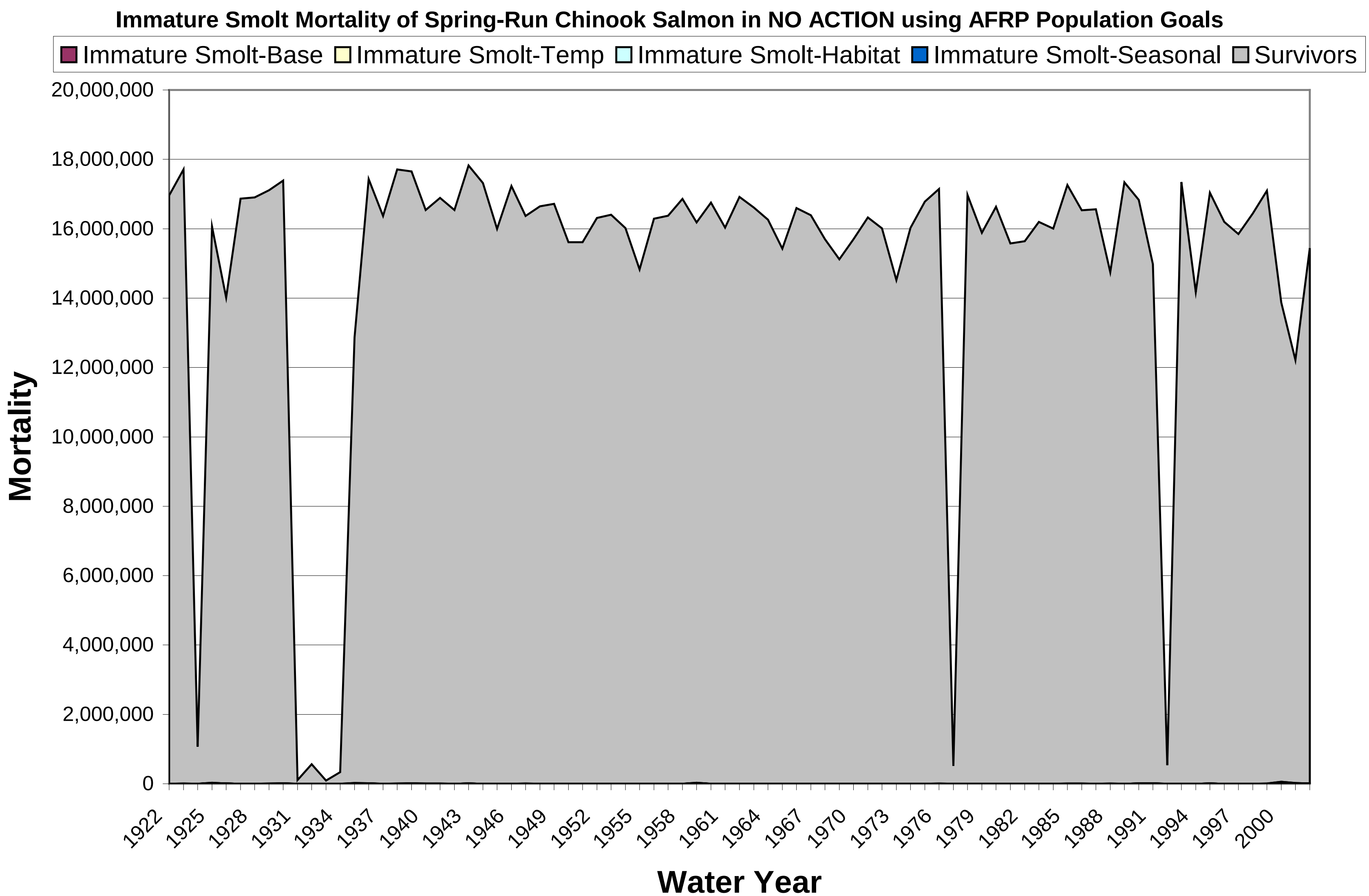

Figure B-32A. Source of mortality of spring-run Chinook salmon immature smolts in NO ACTION based on the AFRP population goals.

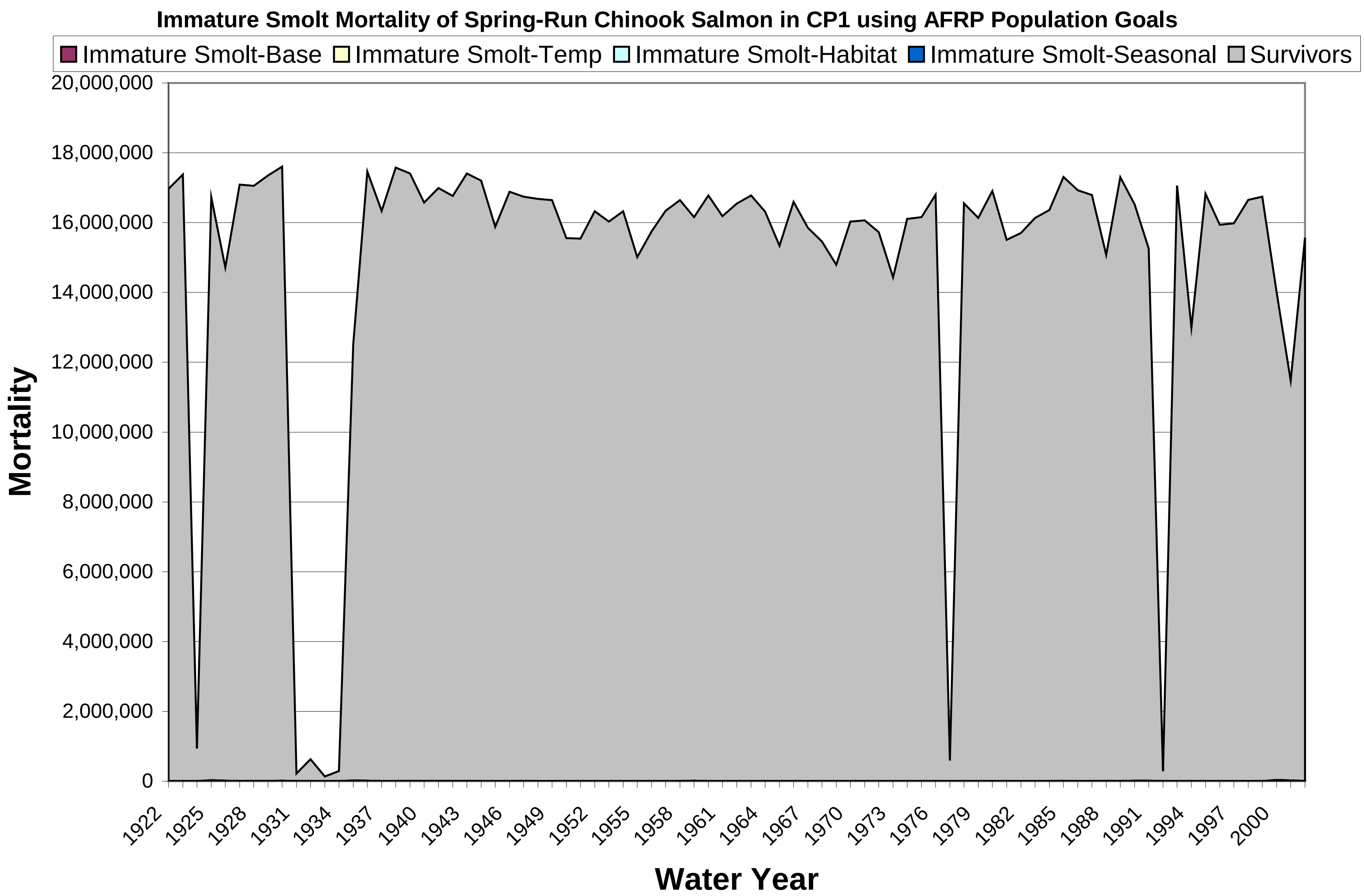

Figure B-32B. Source of mortality of spring-run Chinook salmon immature smolts in CP1 based on the AFRP population goals.

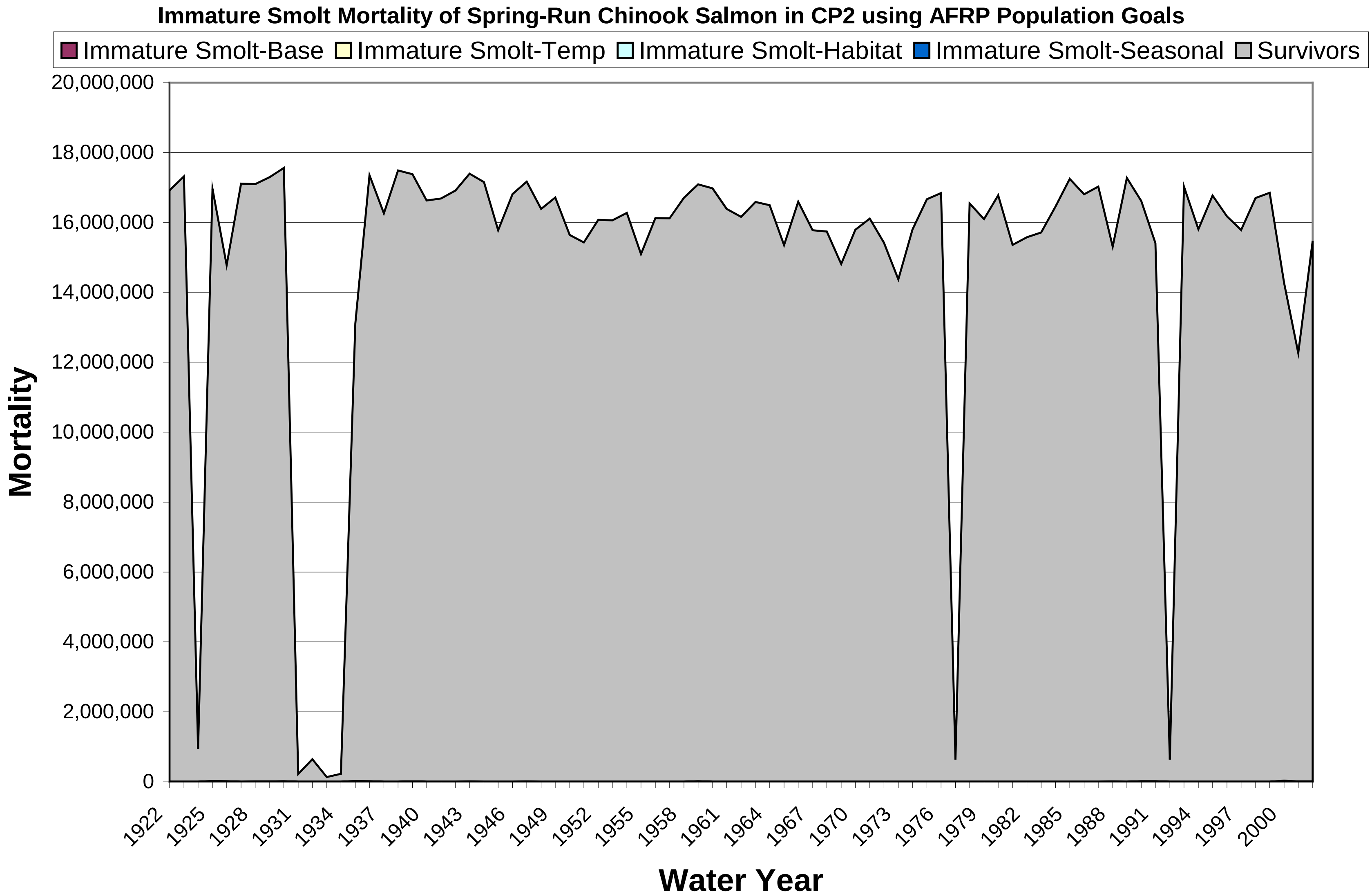

Figure B-32C. Source of mortality of spring-run Chinook salmon immature smolts in CP2 based on the AFRP population goals.

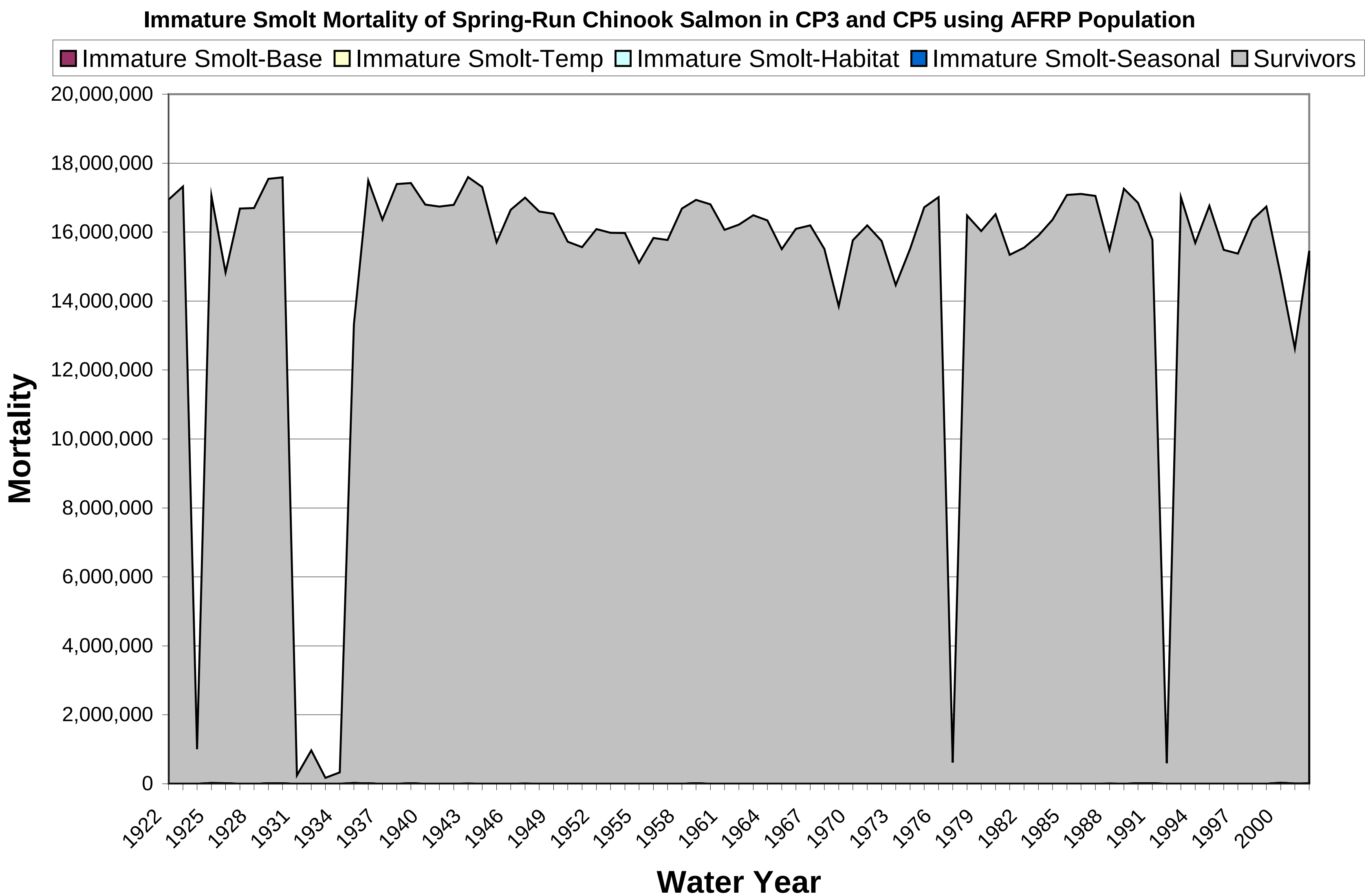

Figure B-32D. Source of mortality of spring-run Chinook salmon immature smolts in CP3 and CP5 based on the AFRP population goals.

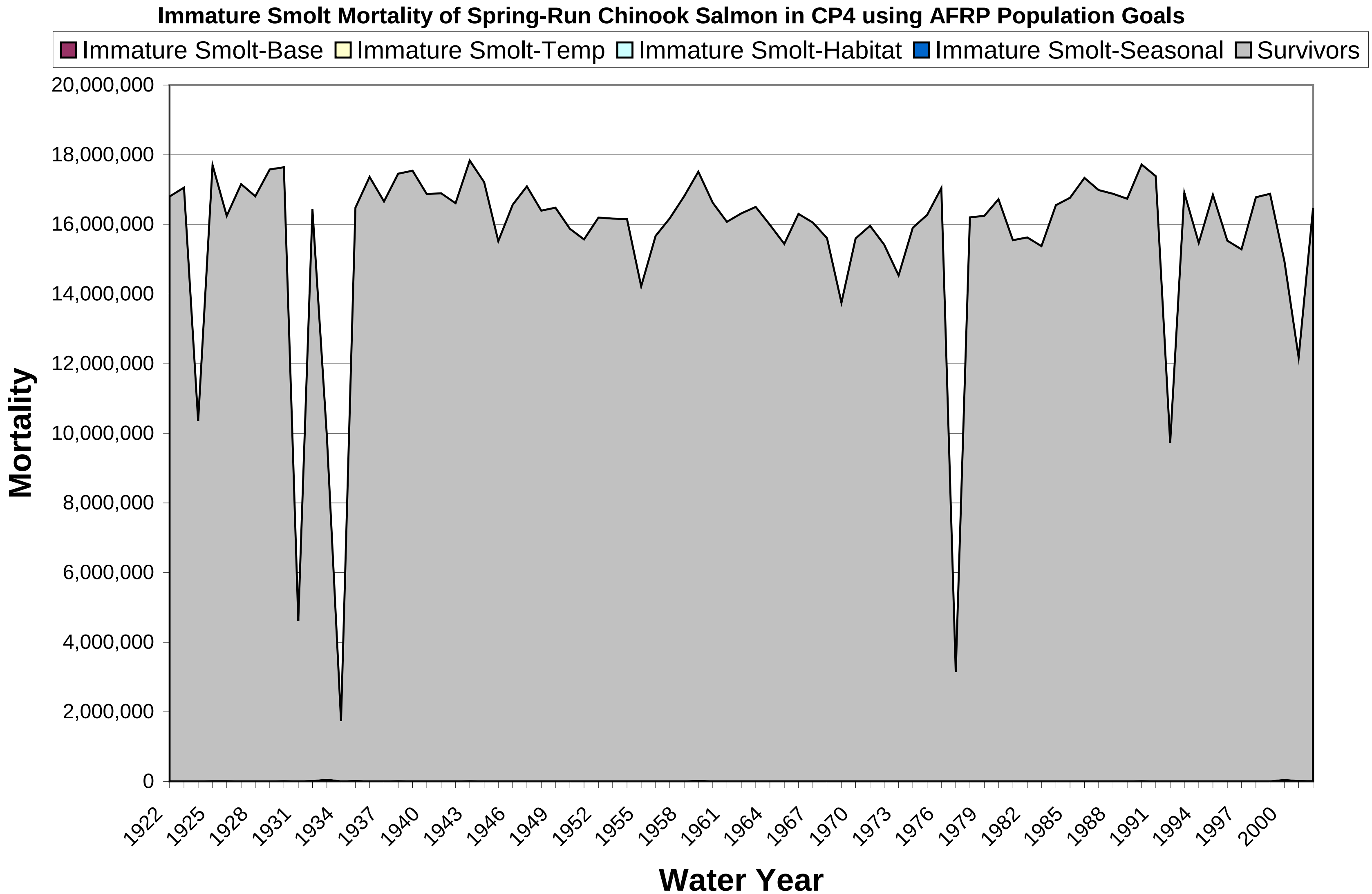

Figure B-32E. Source of mortality of spring-run Chinook salmon immature smolts in CP4 based on the AFRP population goals.

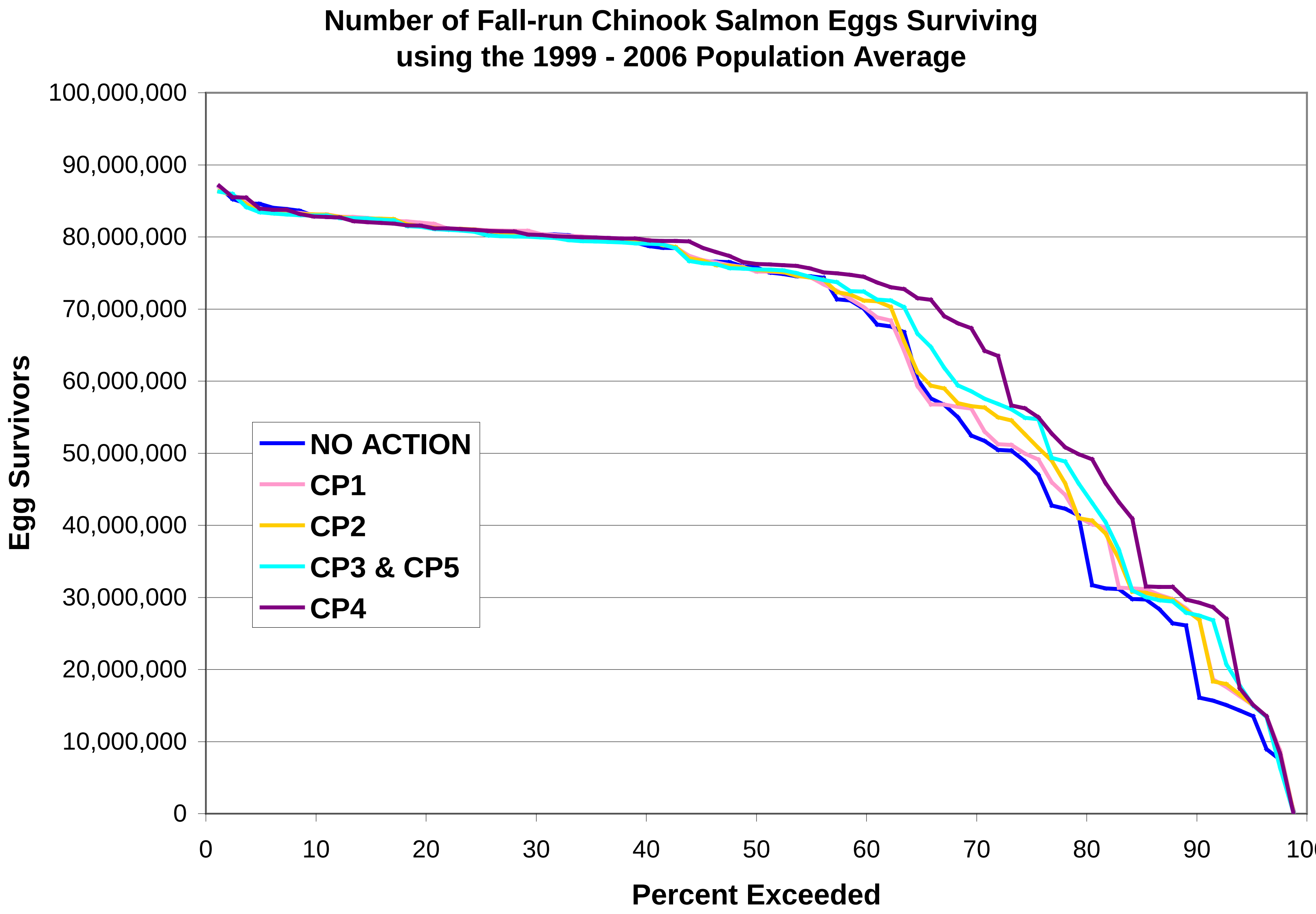

Figure B-33A. Frequency distribution of the number of fall-run Chinook salmon egg survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

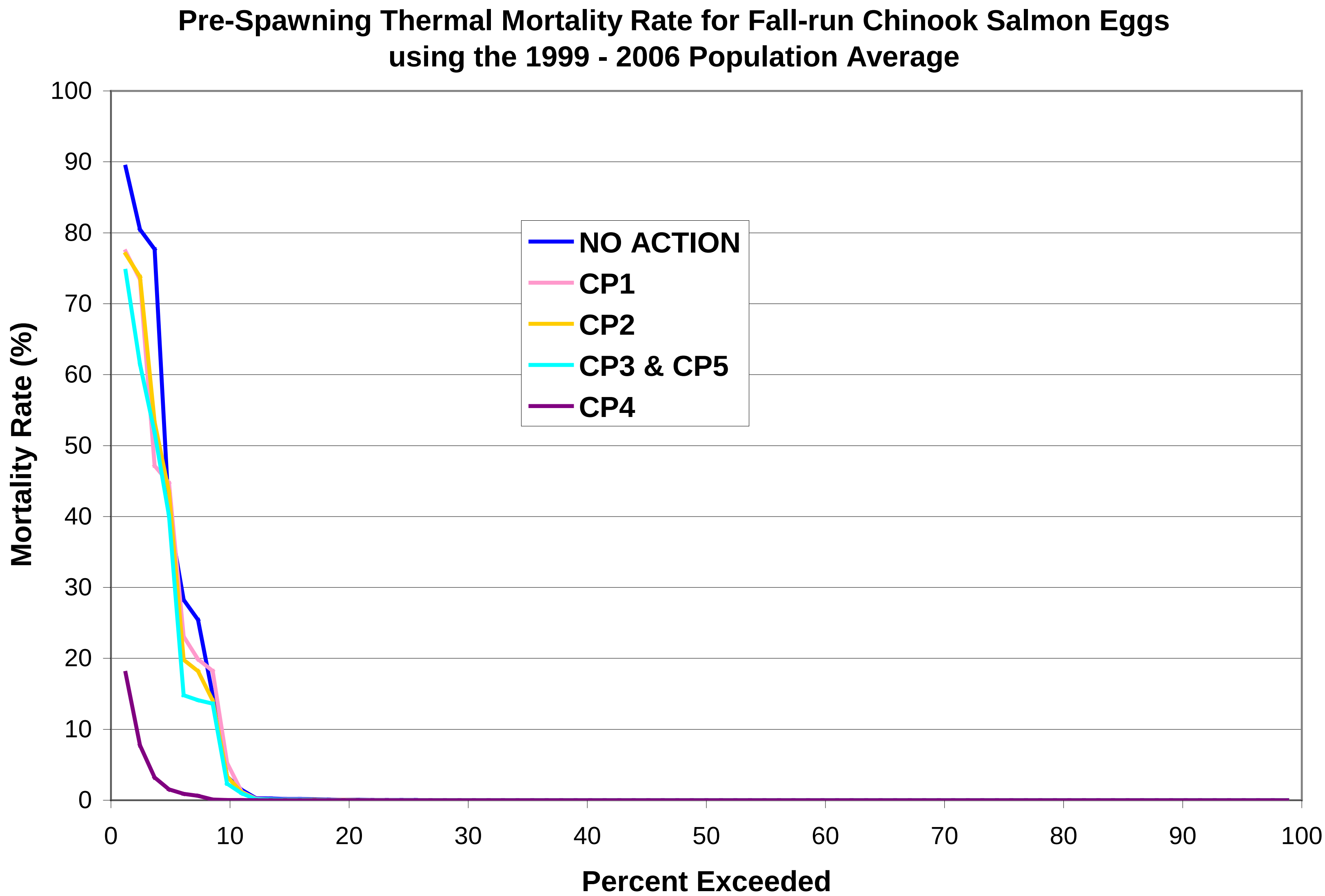

Figure B-33B. Frequency distribution of the pre-spawning mortality rate of fall-run Chinook salmon eggs (*in vivo*) during the 1921-2003 simulation period based on the 1999-2006 population average.

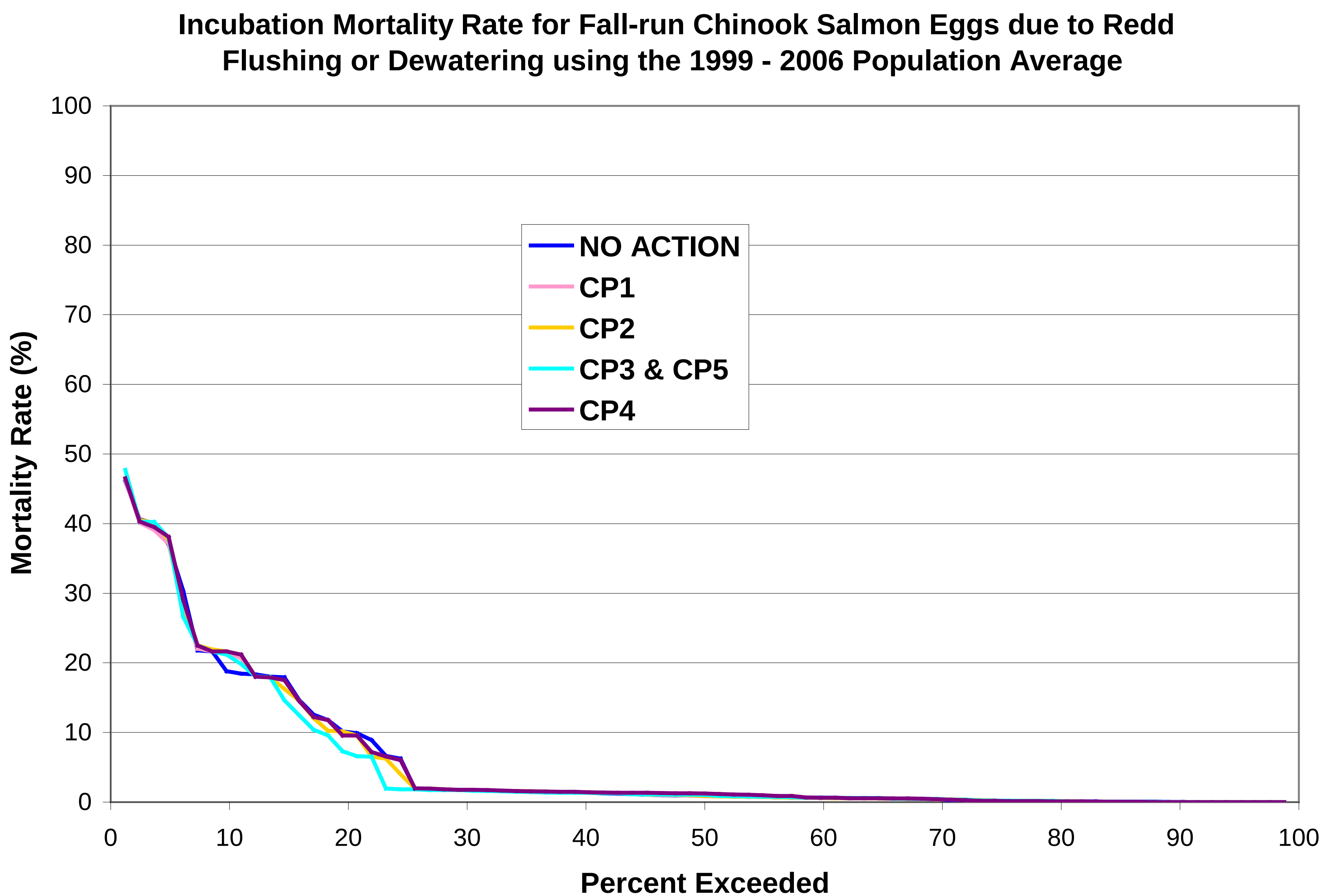

Figure B-33C. Frequency distribution of the incubation mortality rate of fall-run Chinook salmon eggs due to the flushing or dewatering of redds during the 1921-2003 simulation period based on the 1999-2006 population average.

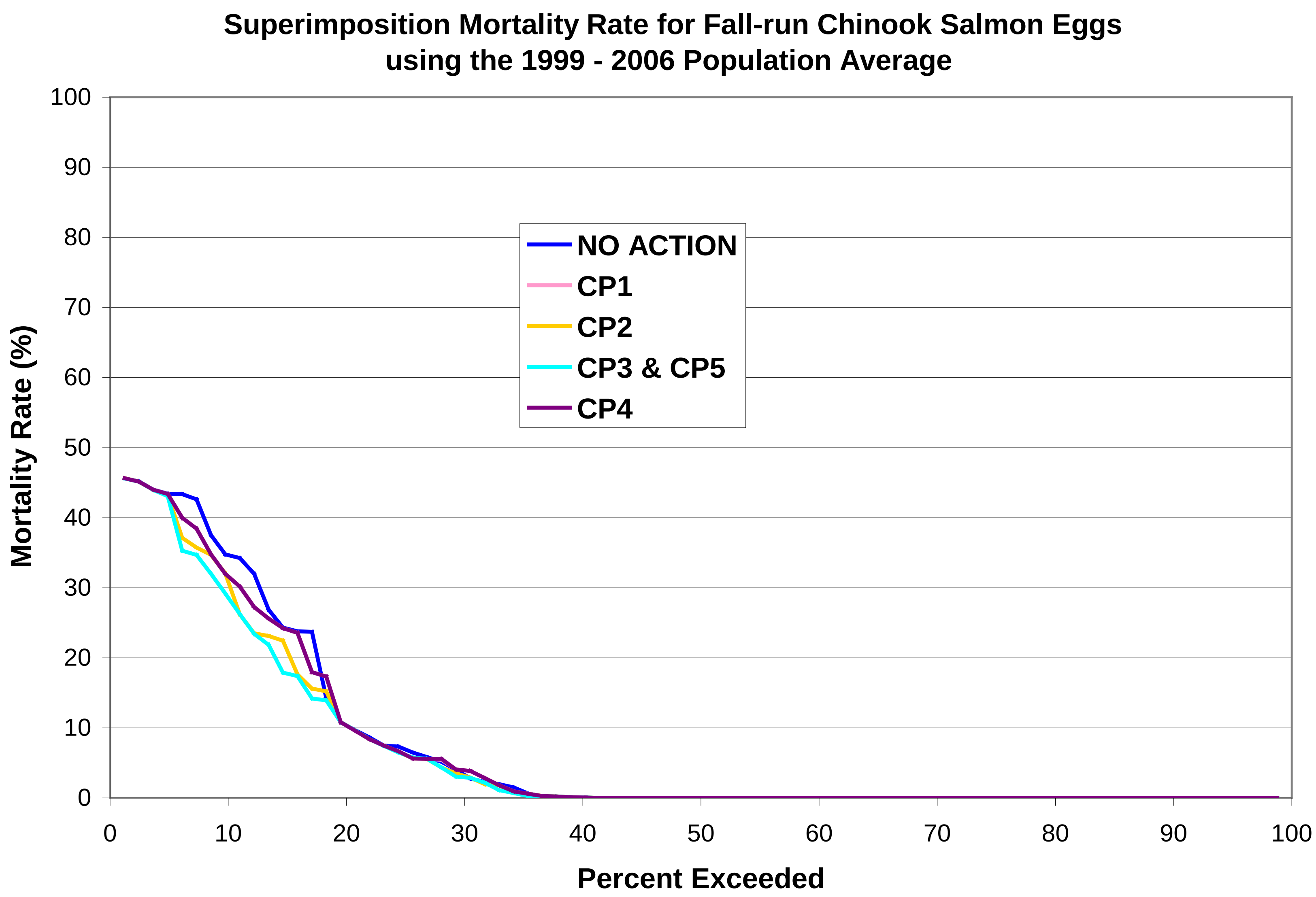

Figure B-33D. Frequency distribution of the superimposition mortality rate of fall-run Chinook salmon eggs during the 1921-2003 simulation period based on the 1999-2006 population average.

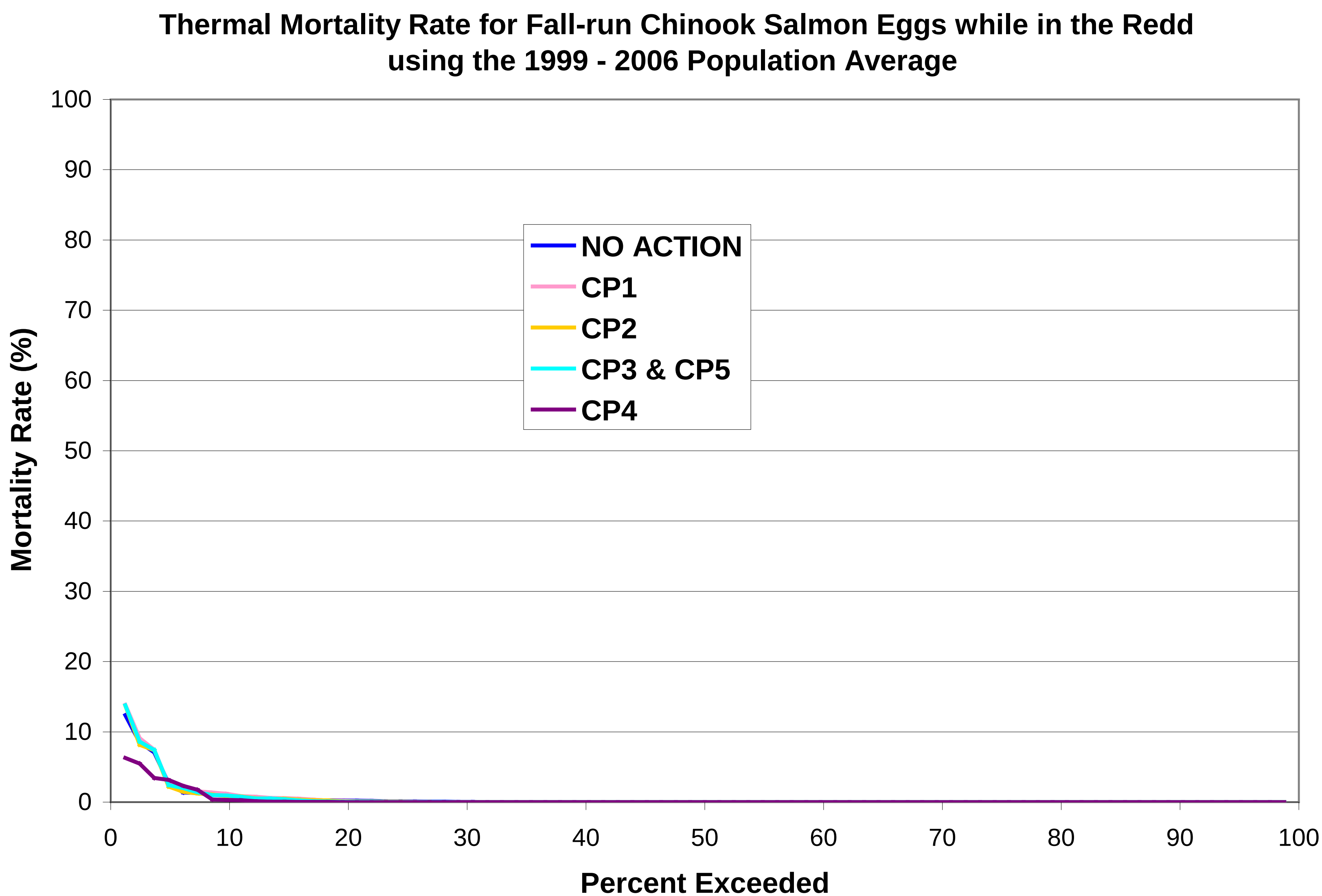

Figure B-33E. Frequency distribution of the thermal mortality rate of fall-run Chinook salmon eggs while in the redd during the 1921-2003 simulation period based on the 1999-2006 population average.

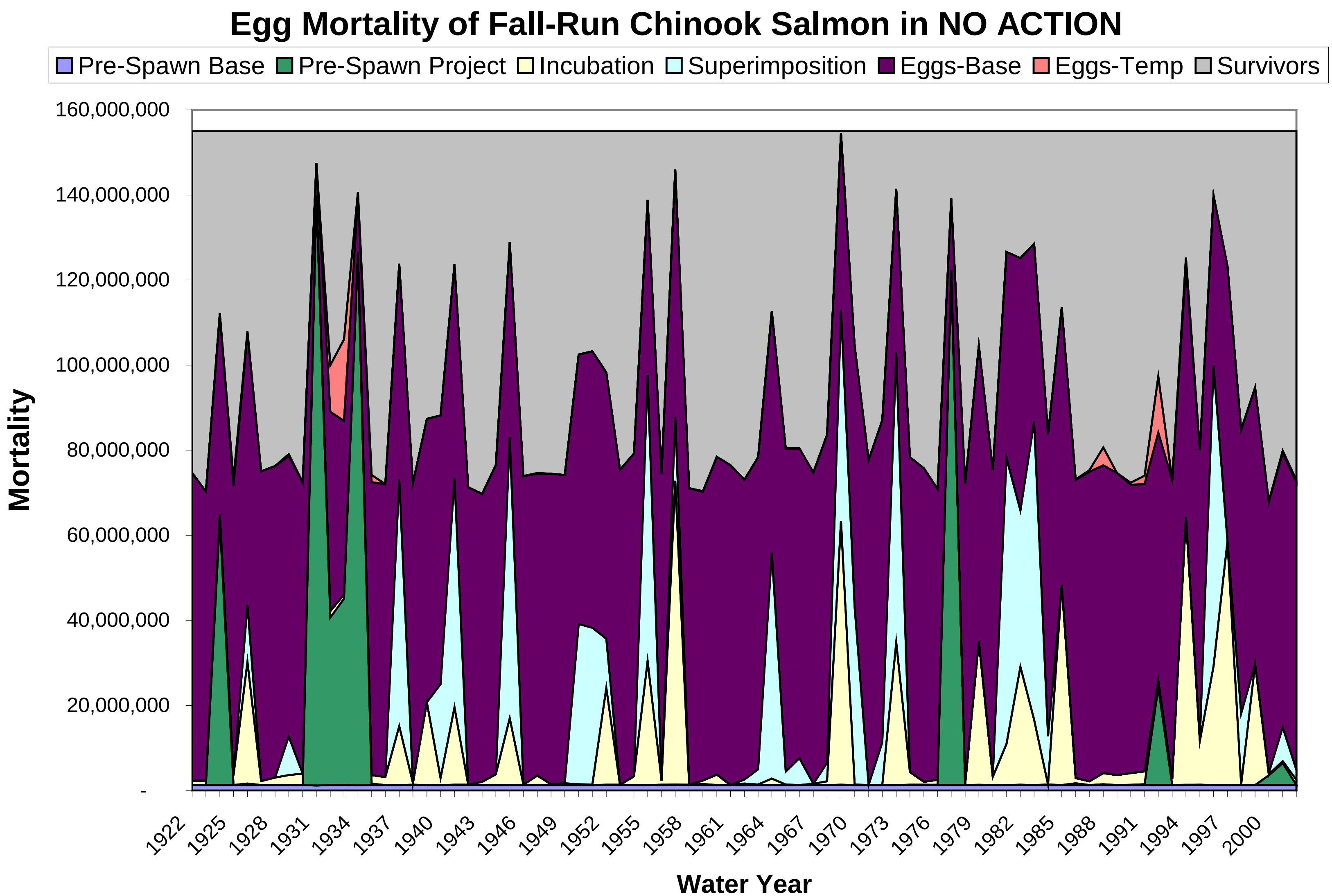

Figure B-34A. Source of mortality of fall-run Chinook salmon eggs in NO ACTION based on the 1999 – 2006 population average.

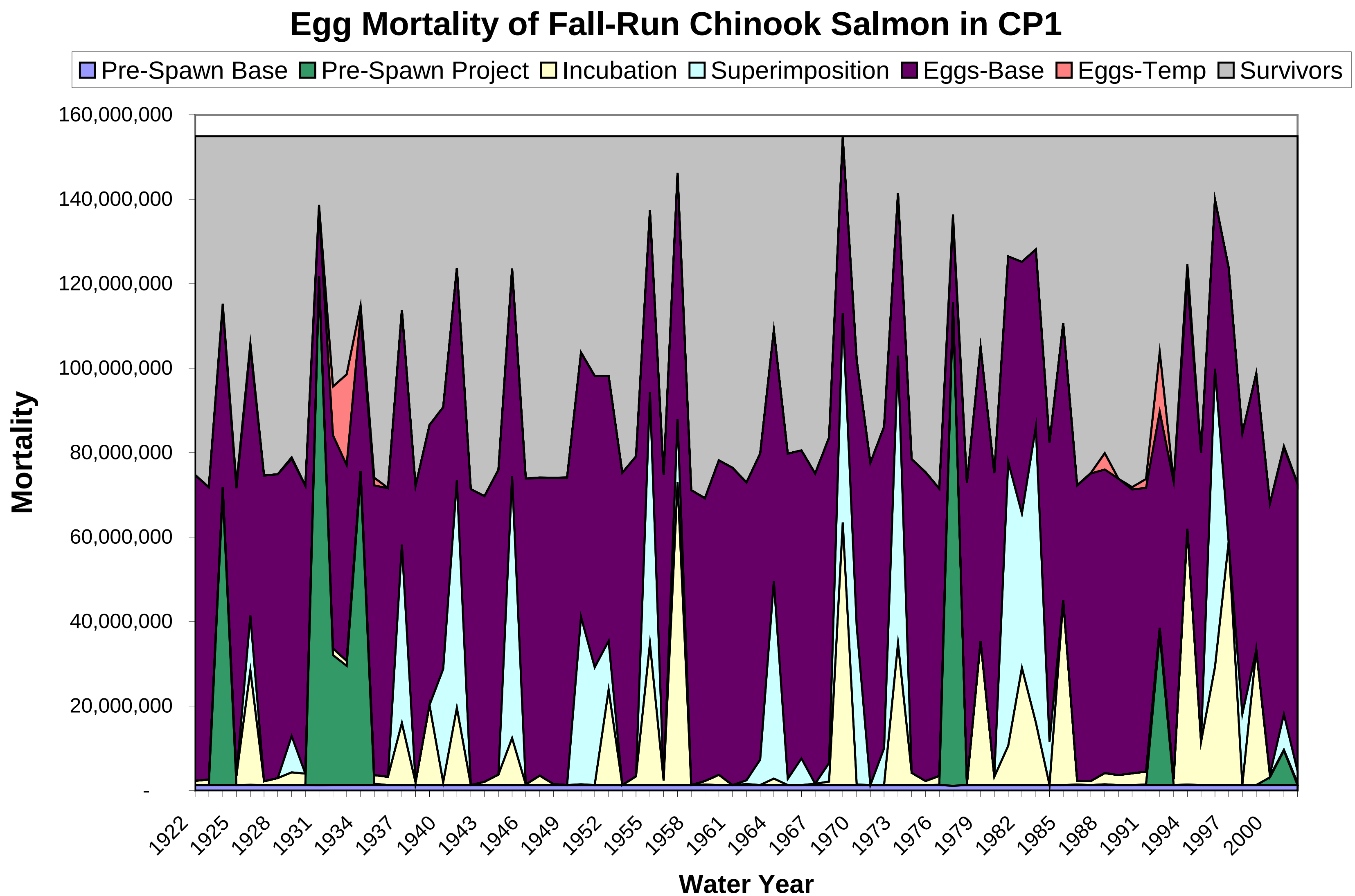

Figure B-34B. Source of mortality of fall-run Chinook salmon eggs in CP1 based on the 1999 – 2006 population average.

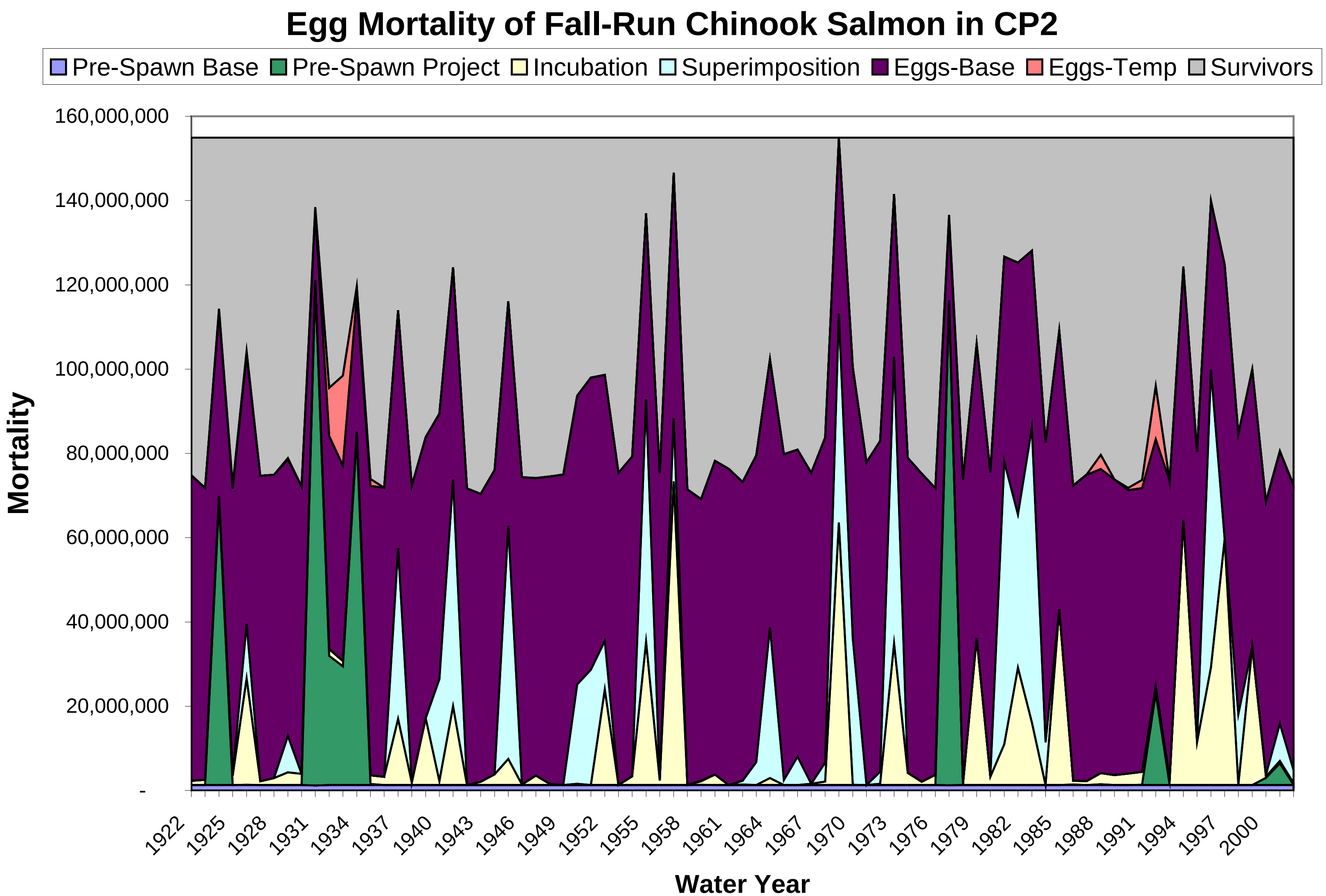

Figure B-34C. Source of mortality of fall-run Chinook salmon eggs in CP2 based on the 1999 – 2006 population average.

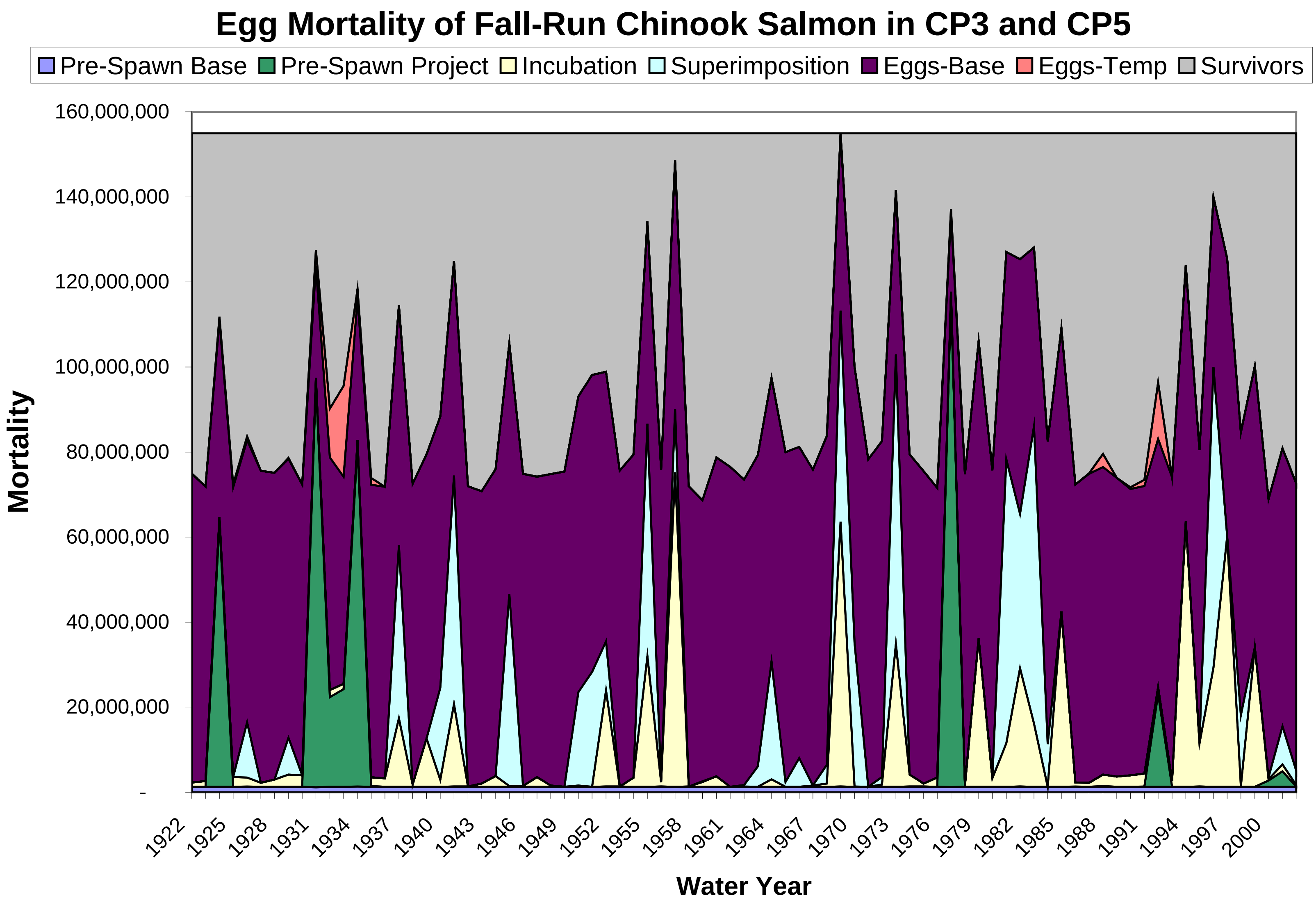

Figure B-34D. Source of mortality of fall-run Chinook salmon eggs in CP3 and CP5 based on the 1999 – 2006 population average.

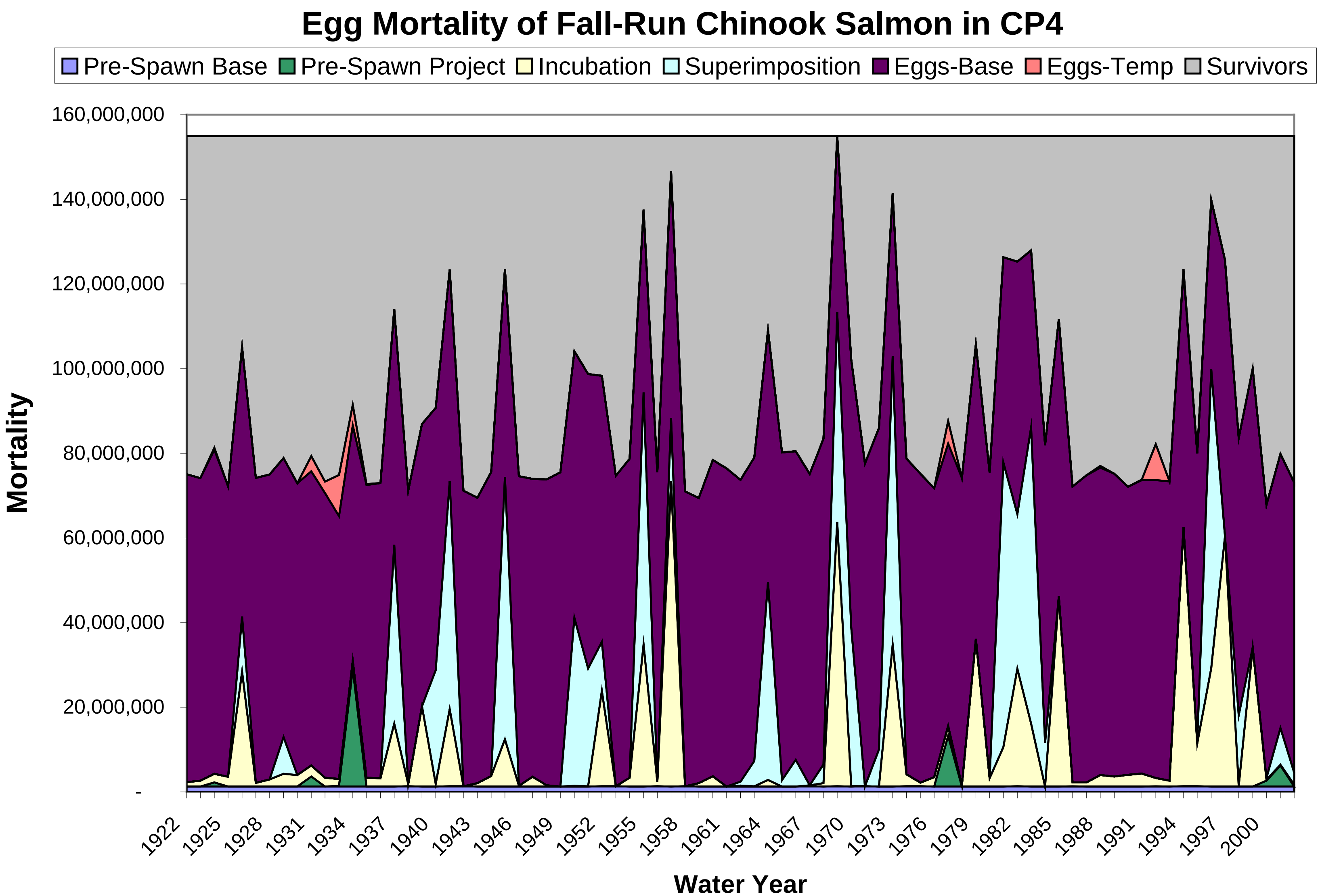

Figure B-34E. Source of mortality of fall-run Chinook salmon eggs in CP4 based on the 1999 – 2006 population average.

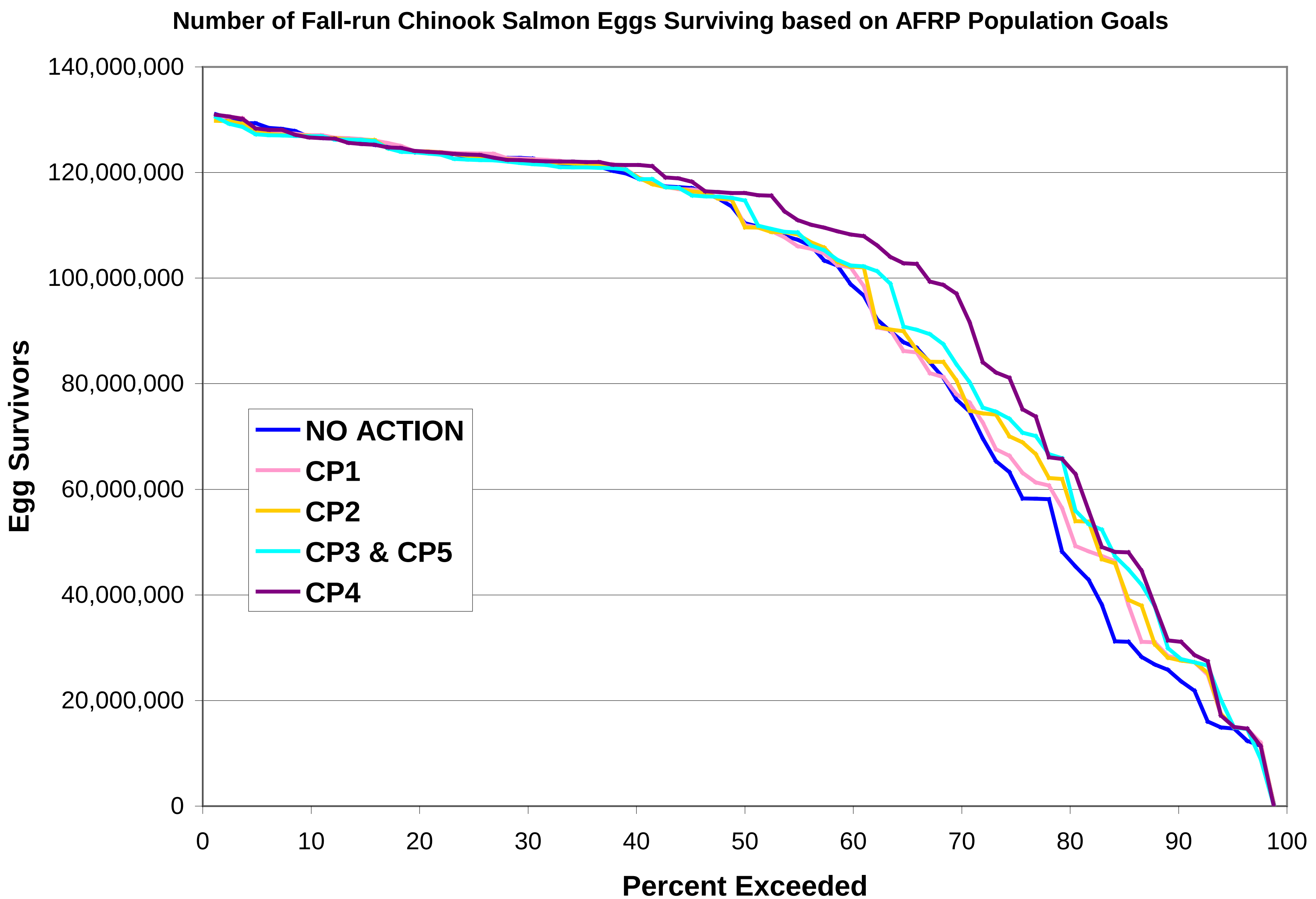

Figure B-35A. Frequency distribution of the number of fall-run Chinook salmon egg survivors during the 1921-2003 simulation period based on the AFRP population goals.

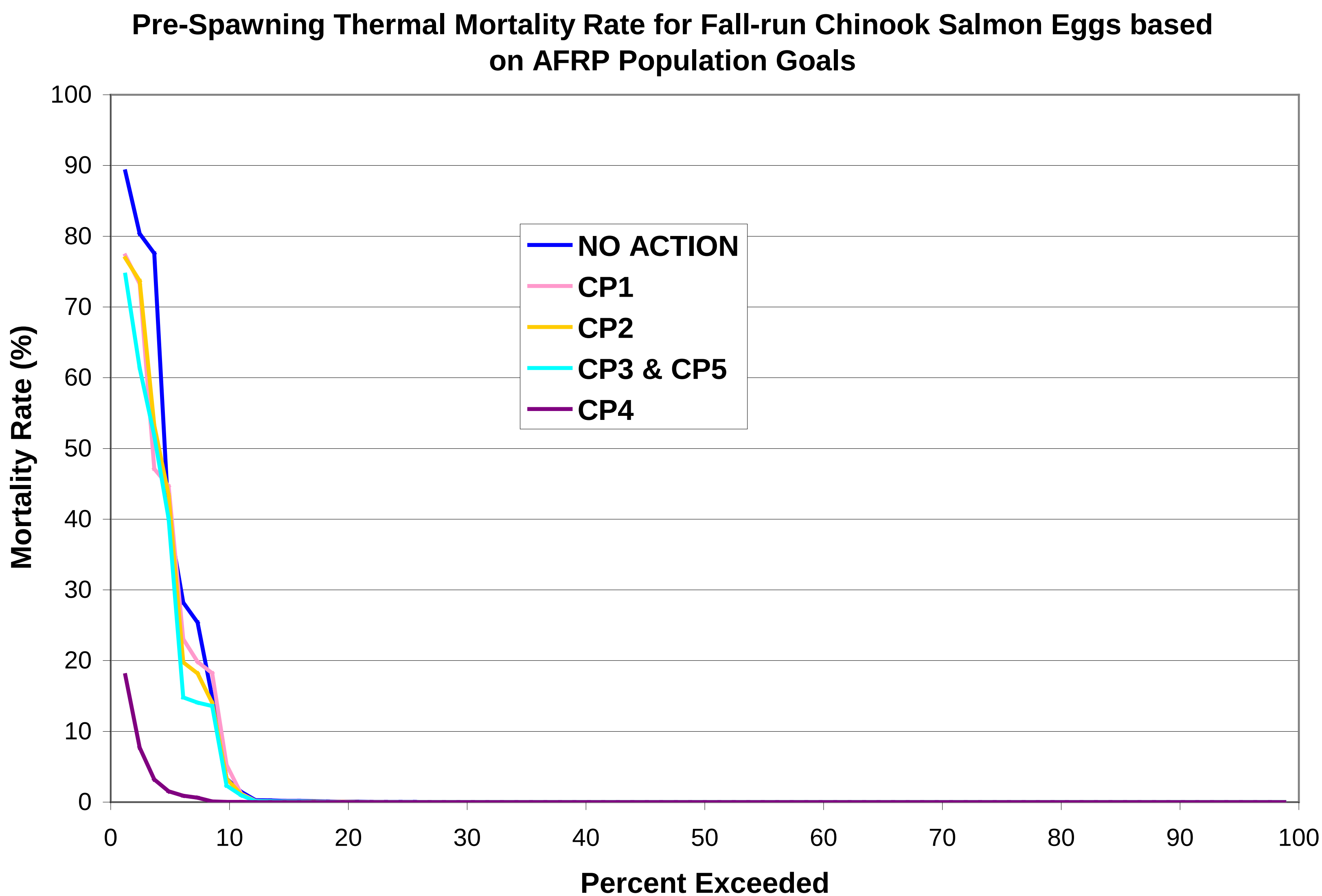

Figure B-35B. Frequency distribution of the pre-spawning mortality rate of fall-run Chinook salmon eggs (*in vivo*) during the 1921-2003 simulation period based on the AFRP population goals.

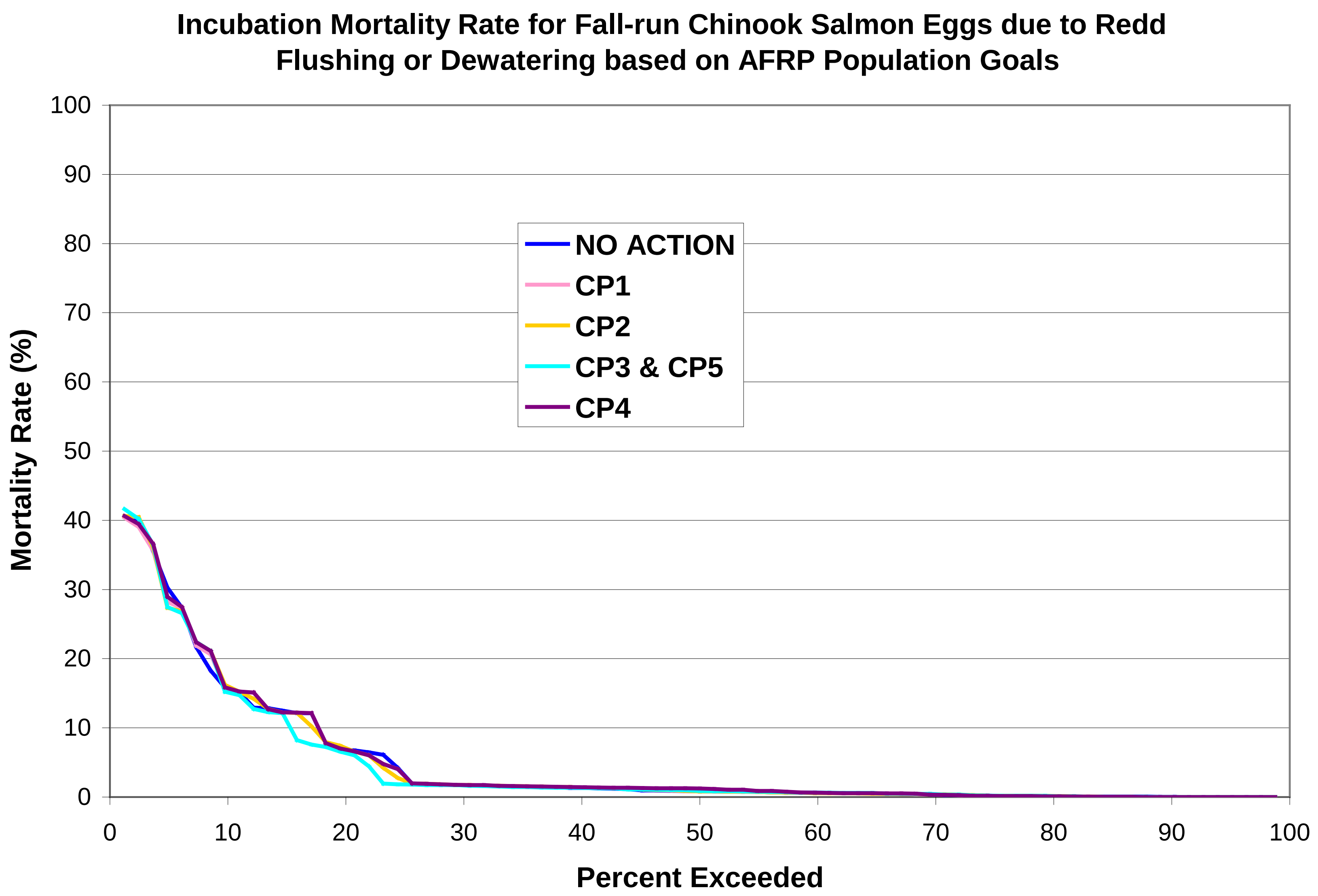

Figure B-35C. Frequency distribution of the incubation mortality rate of fall-run Chinook salmon eggs due to the flushing or dewatering of redds during the 1921-2003 simulation period based on the AFRP population goals.

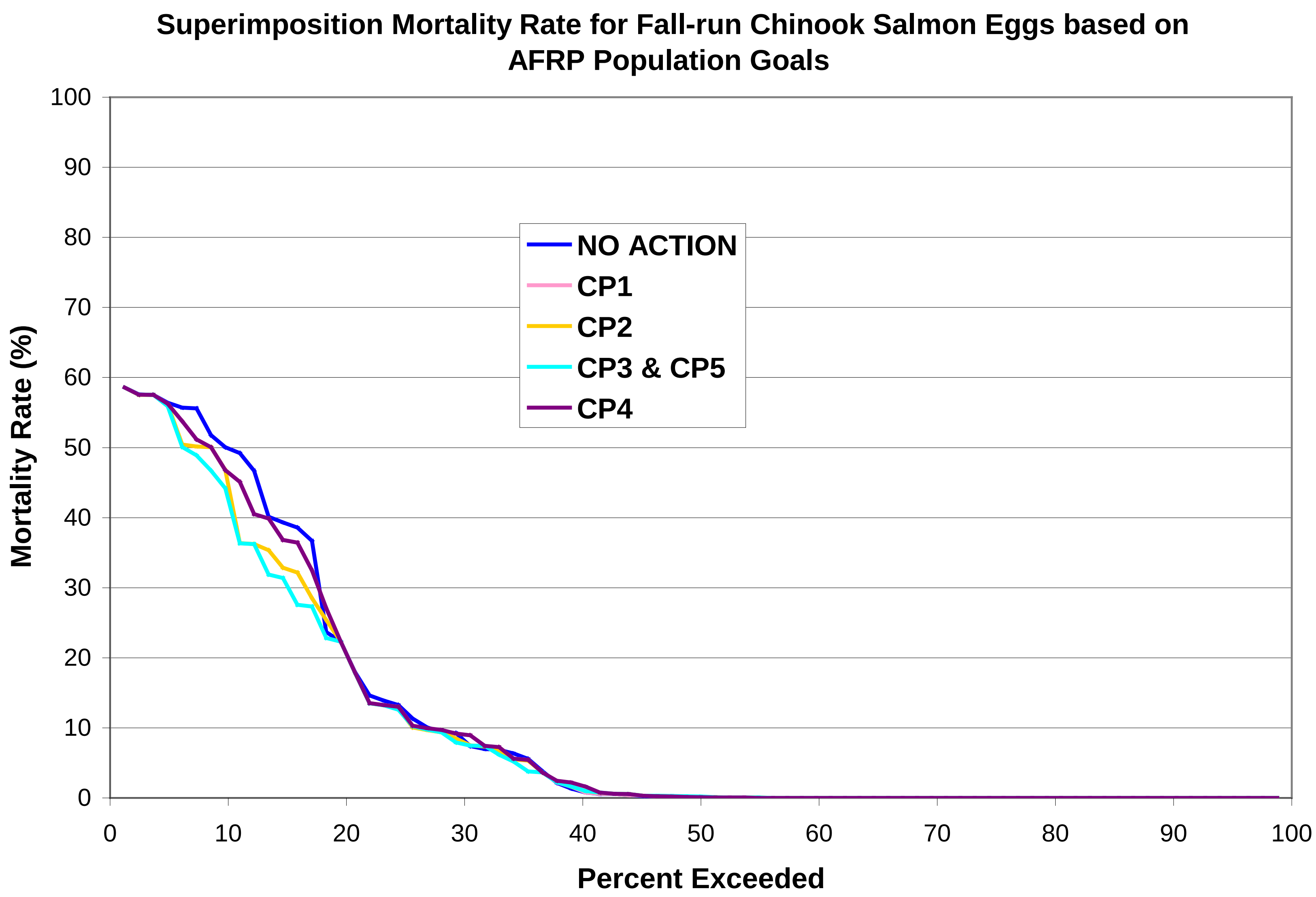

Figure B-35C. Frequency distribution of the superimposition mortality rate of fall-run Chinook salmon eggs during the 1921-2003 simulation period based on the AFRP population goals.

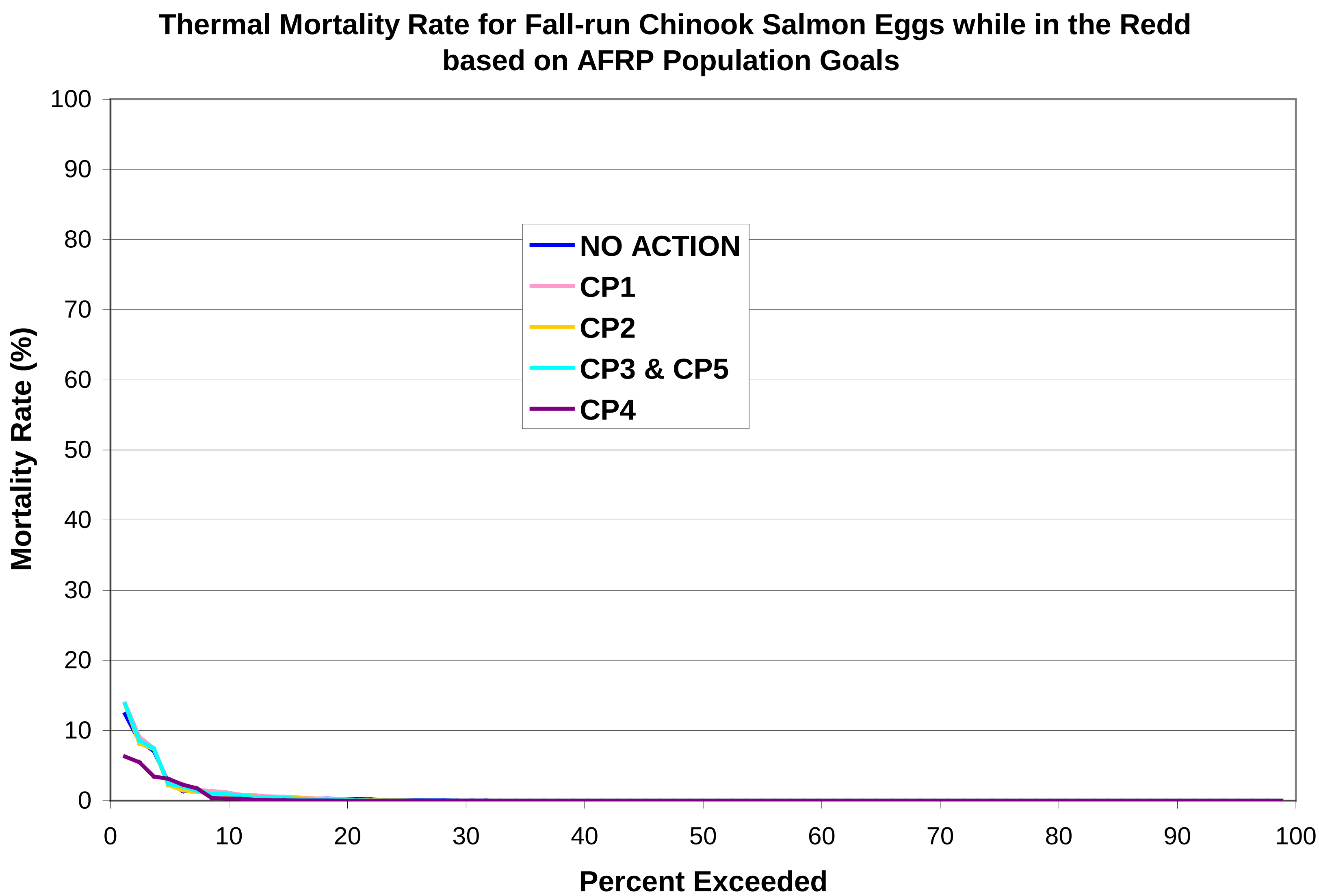

Figure B-35D. Frequency distribution of the thermal mortality rate of fall-run Chinook salmon eggs while in the redd during the 1921-2003 simulation period based on the AFRP population goals.

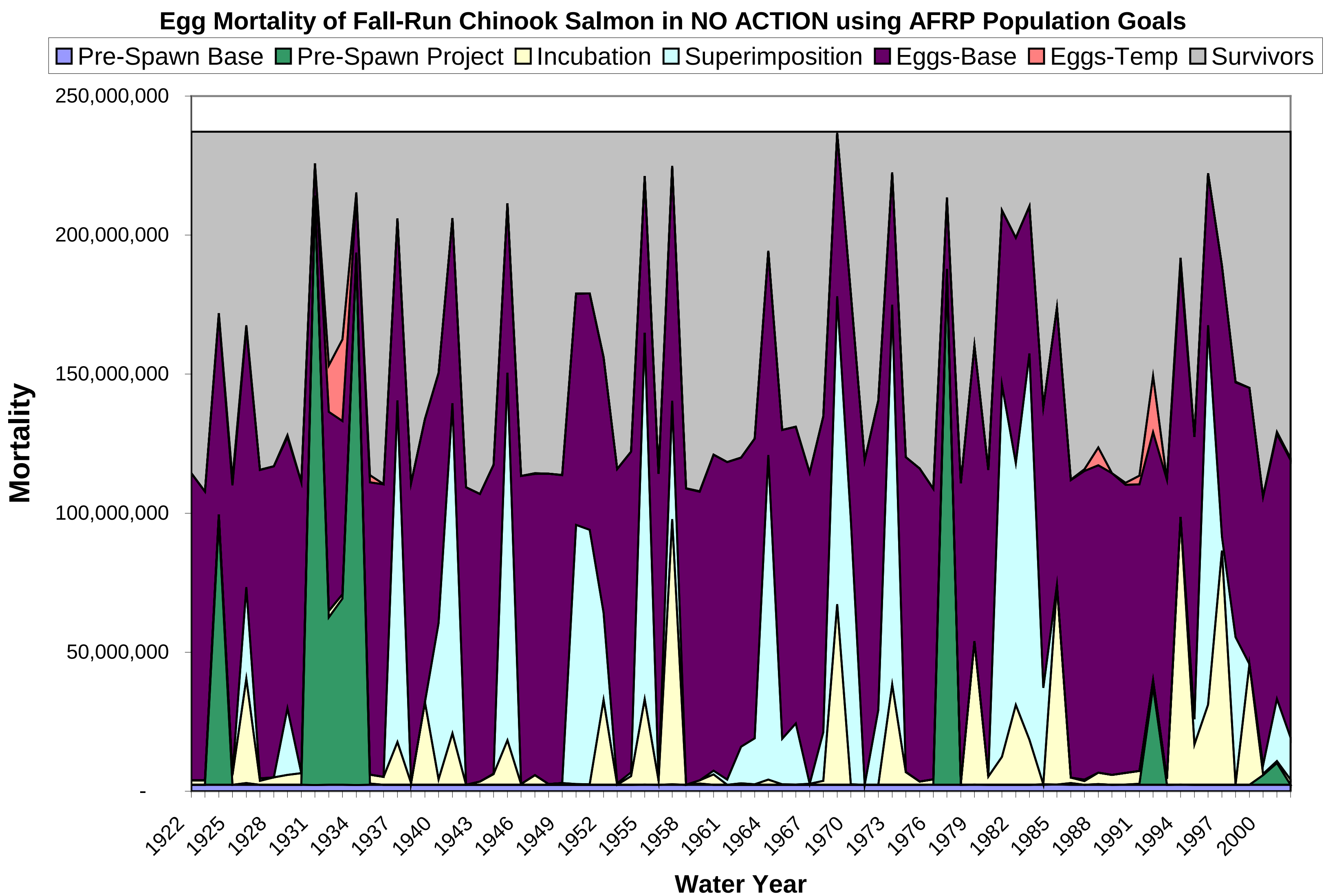

Figure B-36A. Source of mortality of fall-run Chinook salmon eggs in NO ACTION based on AFRP population goals.

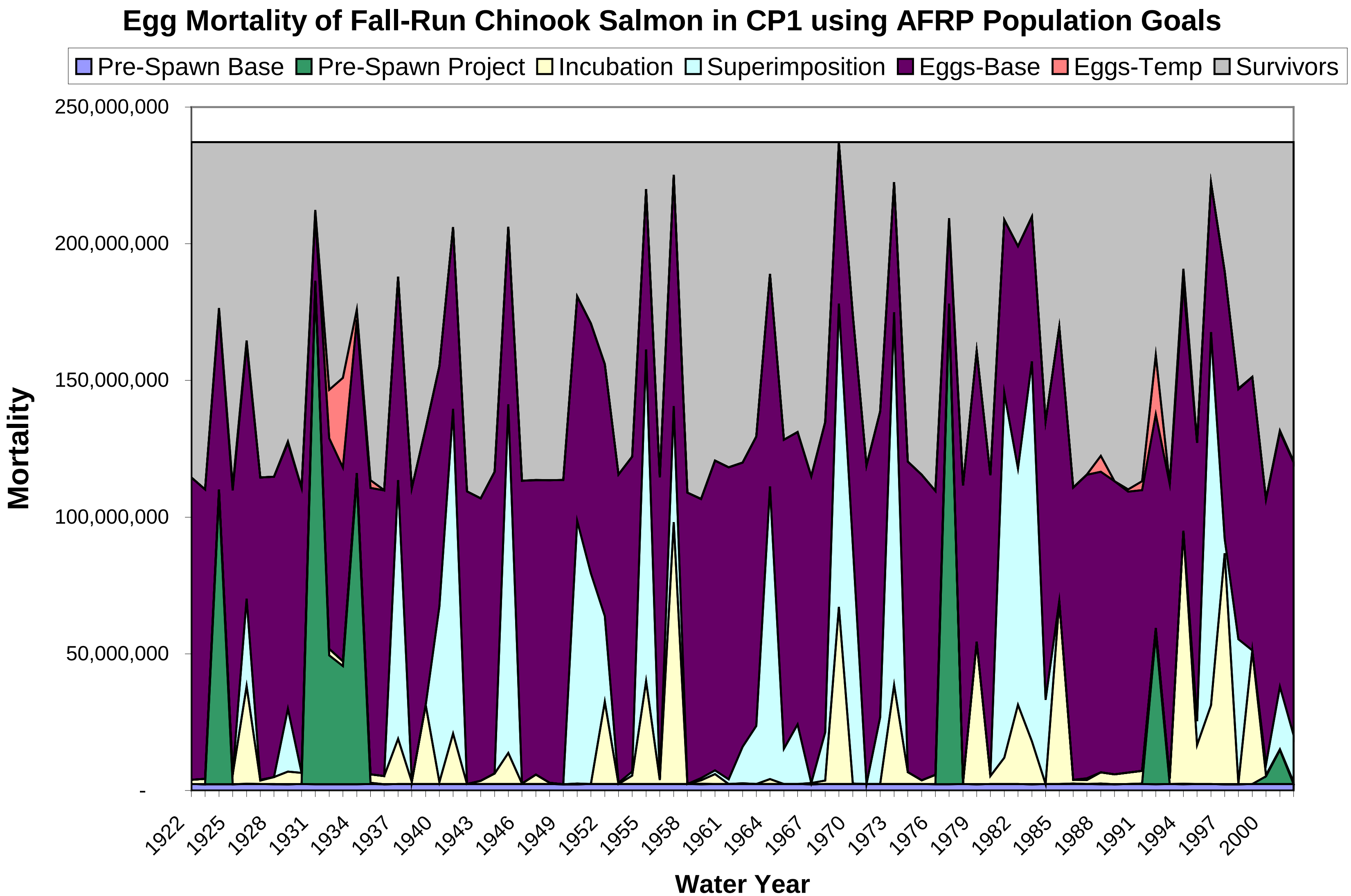

Figure B-36B. Source of mortality of fall-run Chinook salmon eggs in CP1 based on AFRP population goals.

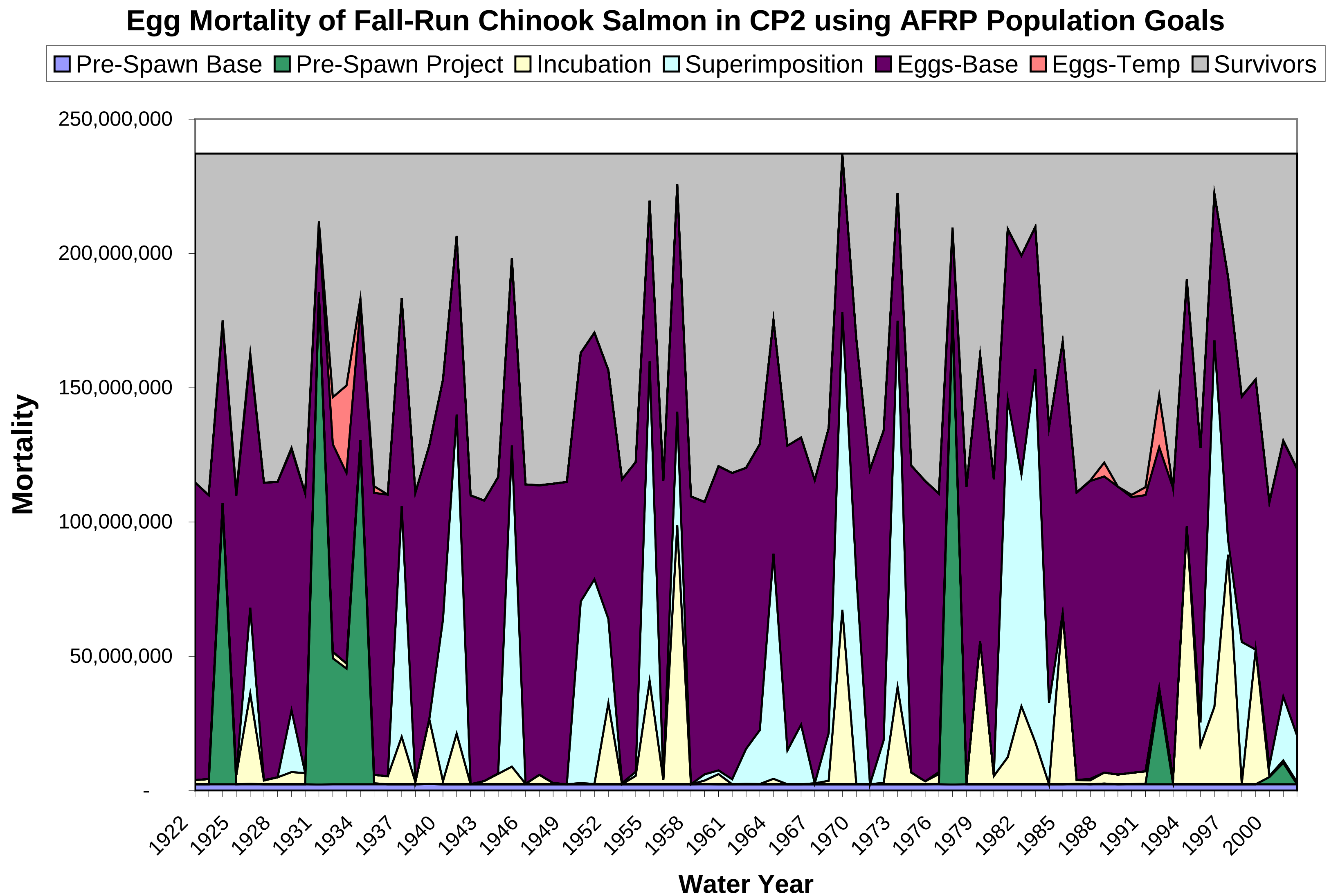

Figure B-36C. Source of mortality of fall-run Chinook salmon eggs in CP2 based on AFRP population goals.

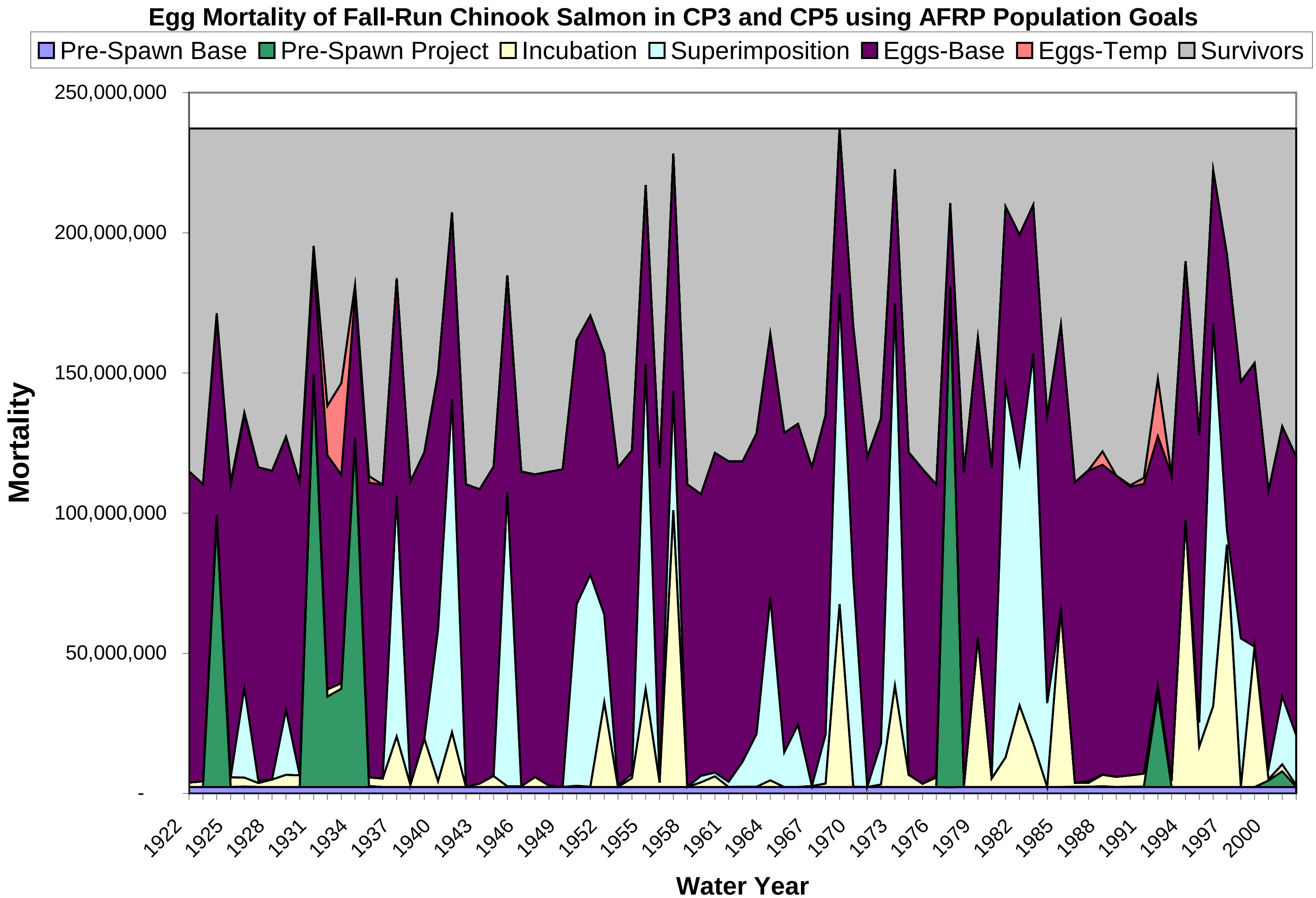

Figure B-36D. Source of mortality of fall-run Chinook salmon eggs in CP3 and CP5 based on AFRP population goals.

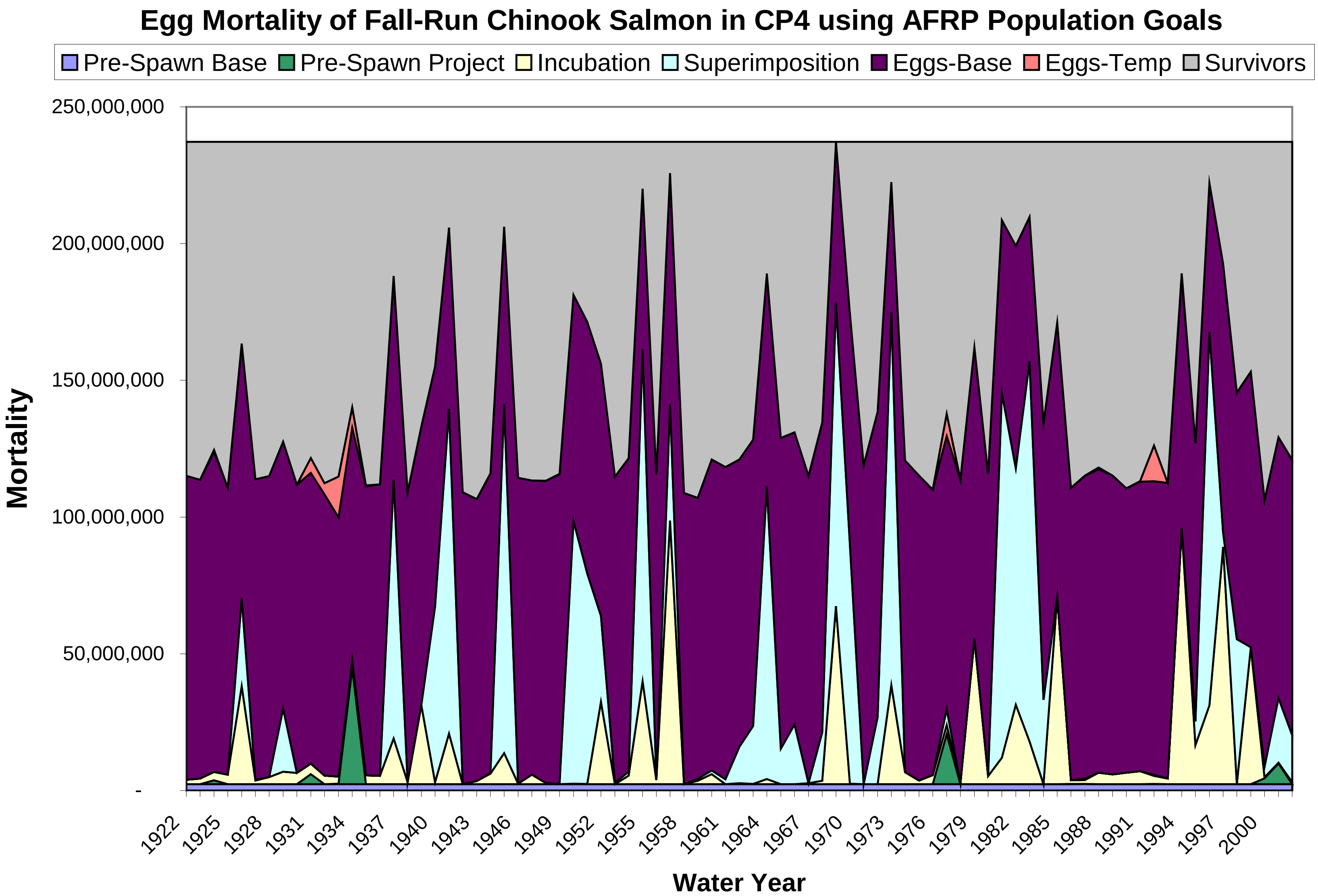

Figure B-36E. Source of mortality of fall-run Chinook salmon eggs in CP4 based on AFRP population goals.

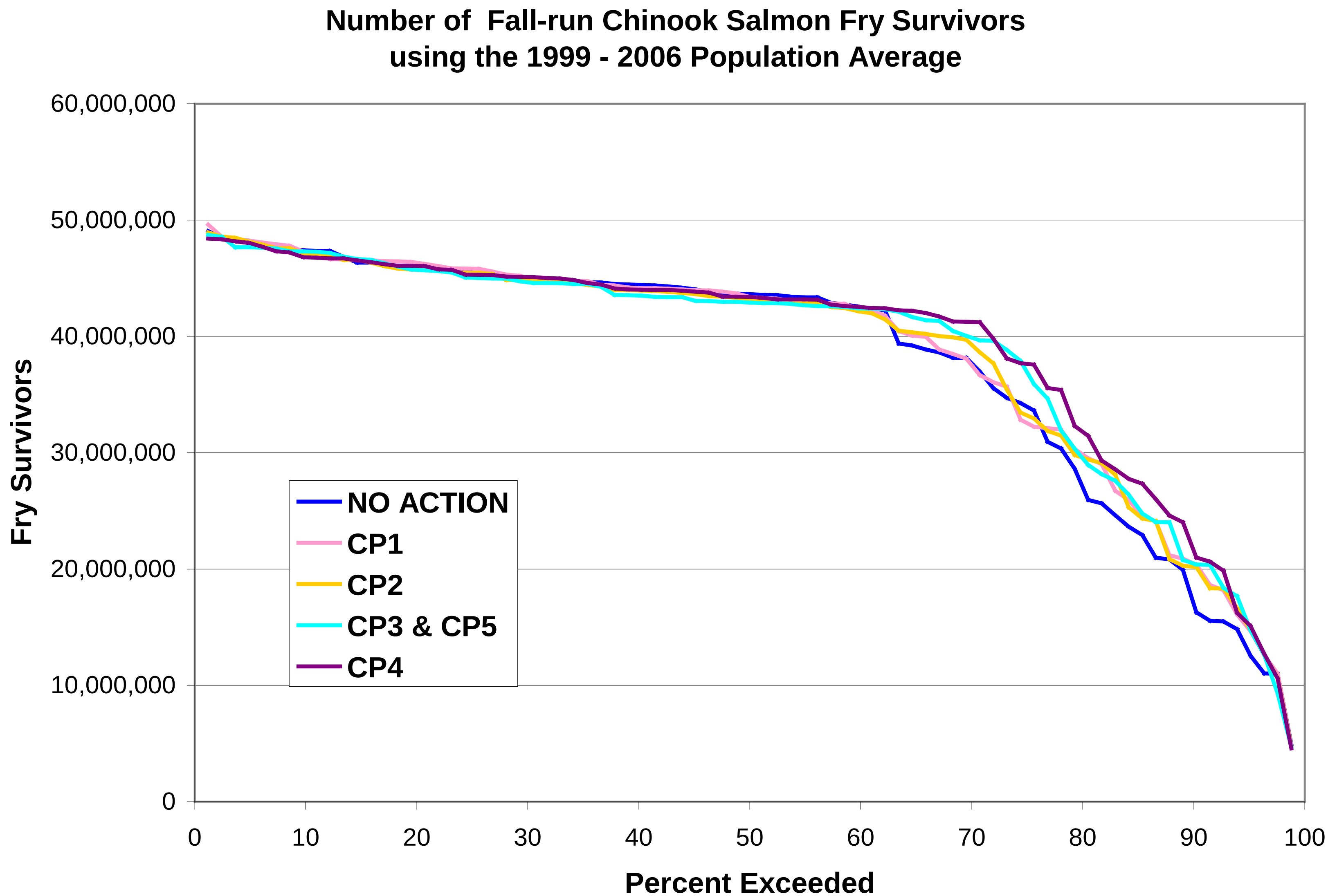

Figure B-37A. Frequency distribution of the number of fall-run Chinook salmon fry survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

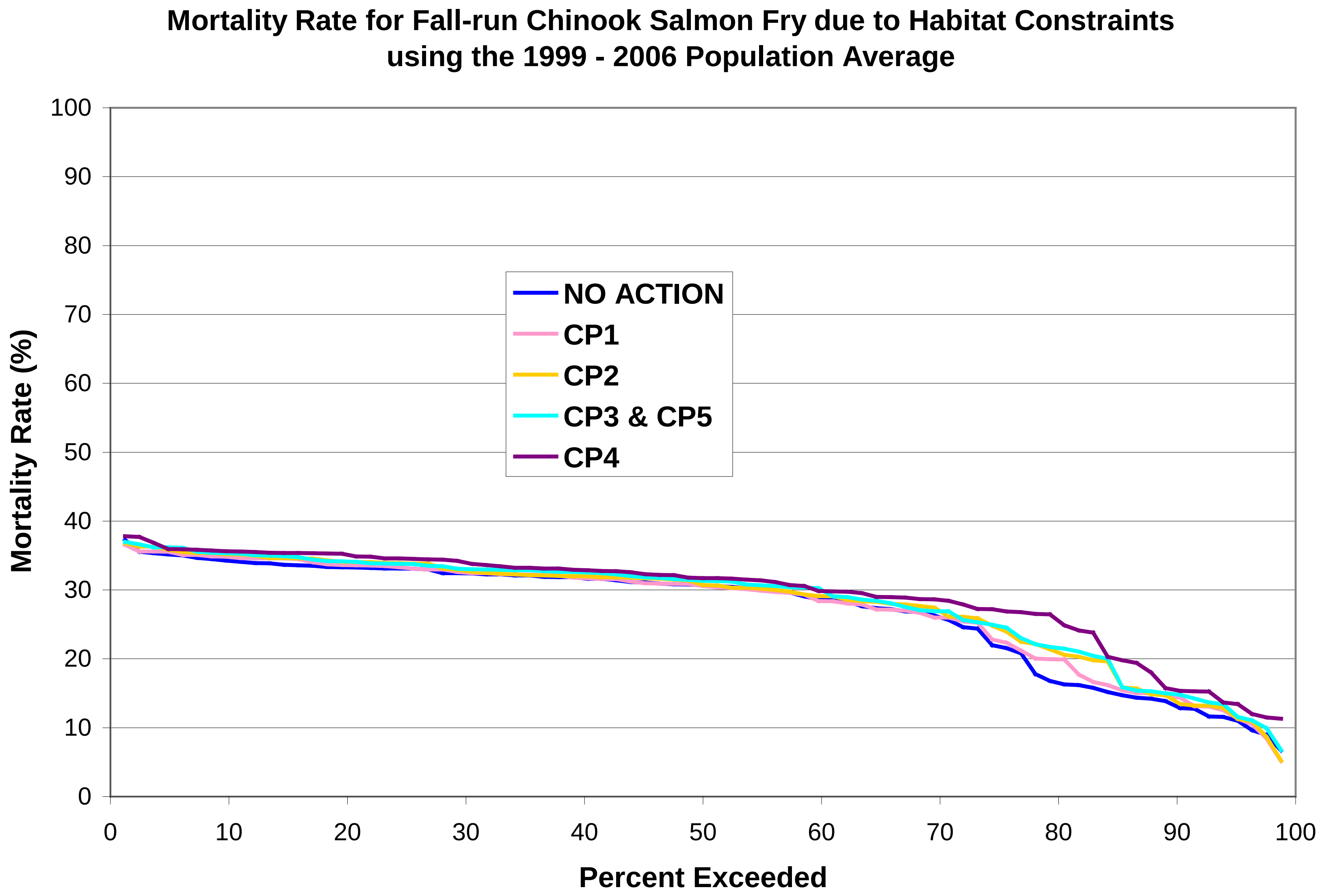

Figure B-37B. Frequency distribution of the mortality rate of fall-run Chinook salmon fry due to habitat constraints (forced movement of fry due to flows or fish density) during the 1921-2003 simulation period based on the 1999-2006 population average.

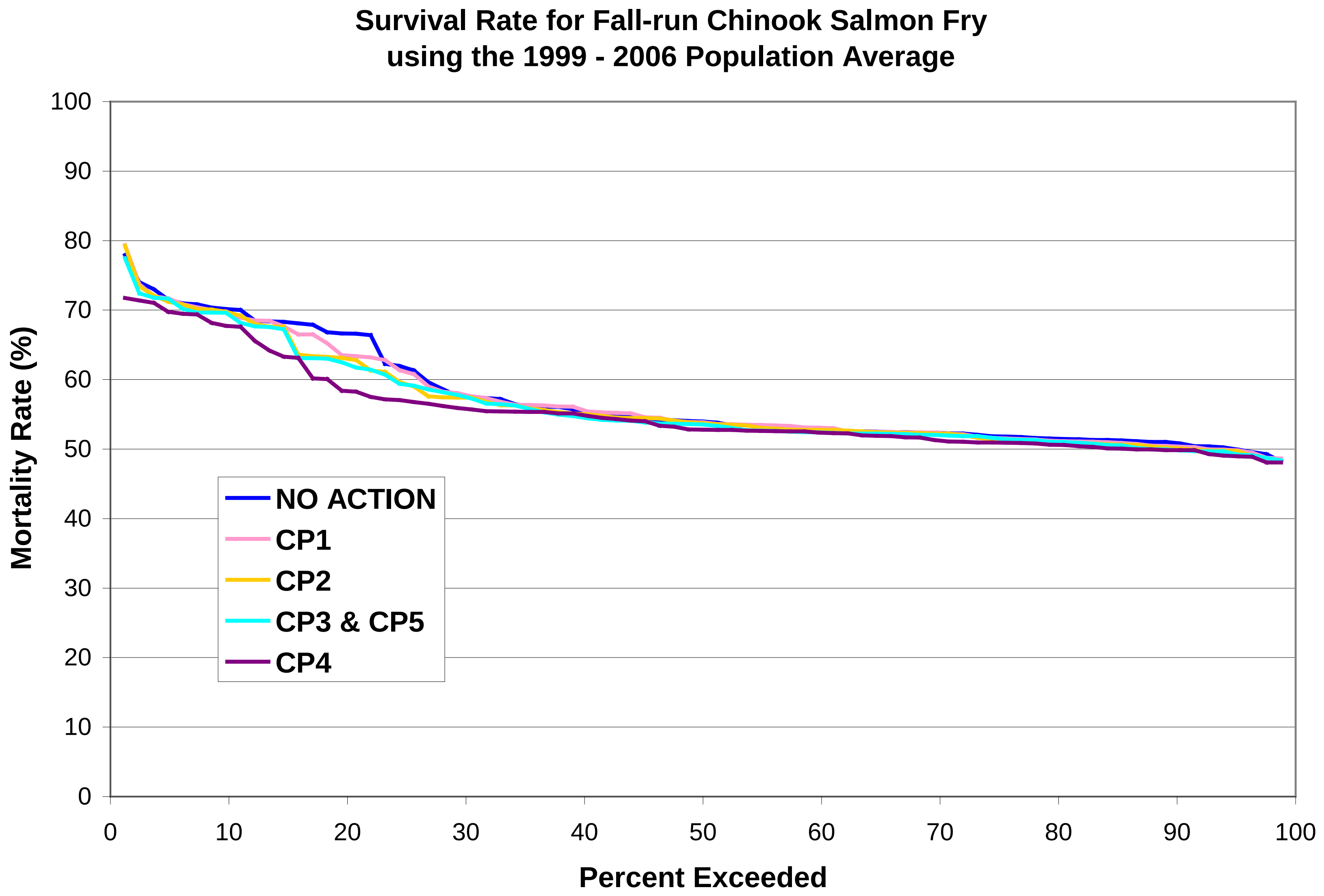

Figure B-37C. Frequency distribution of the survival rate of fall-run Chinook salmon fry during the 1921-2003 simulation period based on the 1999-2006 population average.

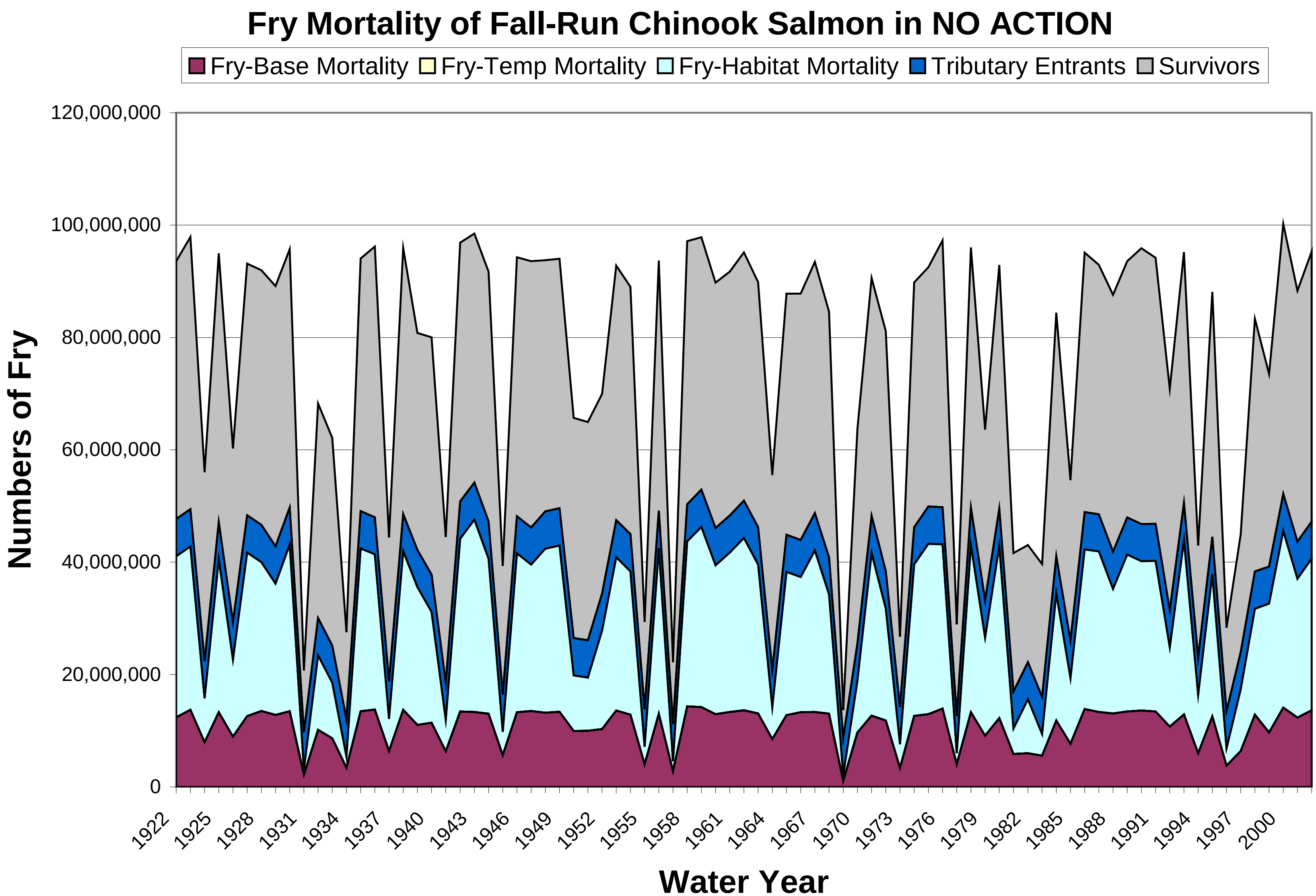

Figure B-38A. Source of mortality of fall-run Chinook salmon fry in NO ACTION based on the 1999 – 2006 population average.

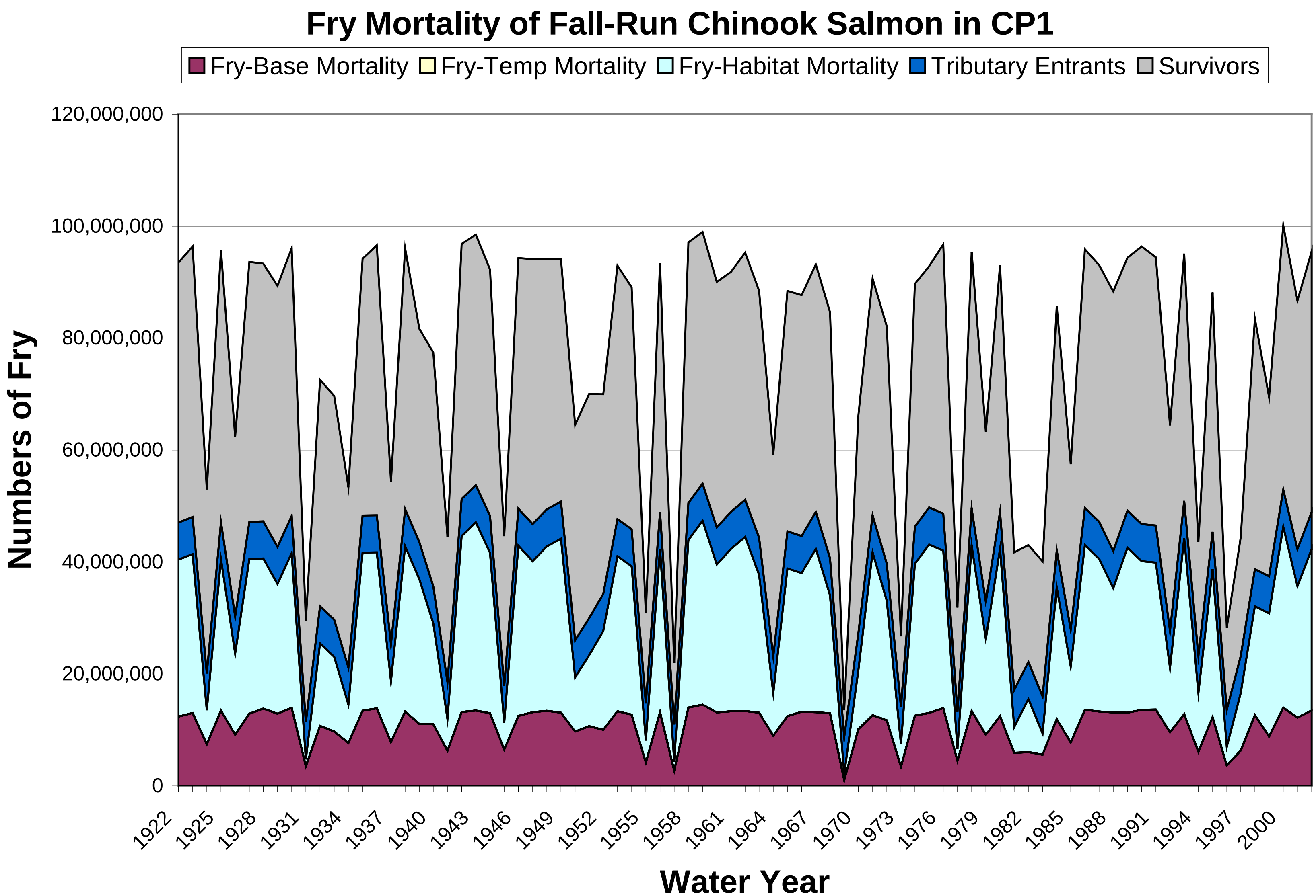

Figure B-38B. Source of mortality of fall-run Chinook salmon fry in CP1 based on the 1999 – 2006 population average.

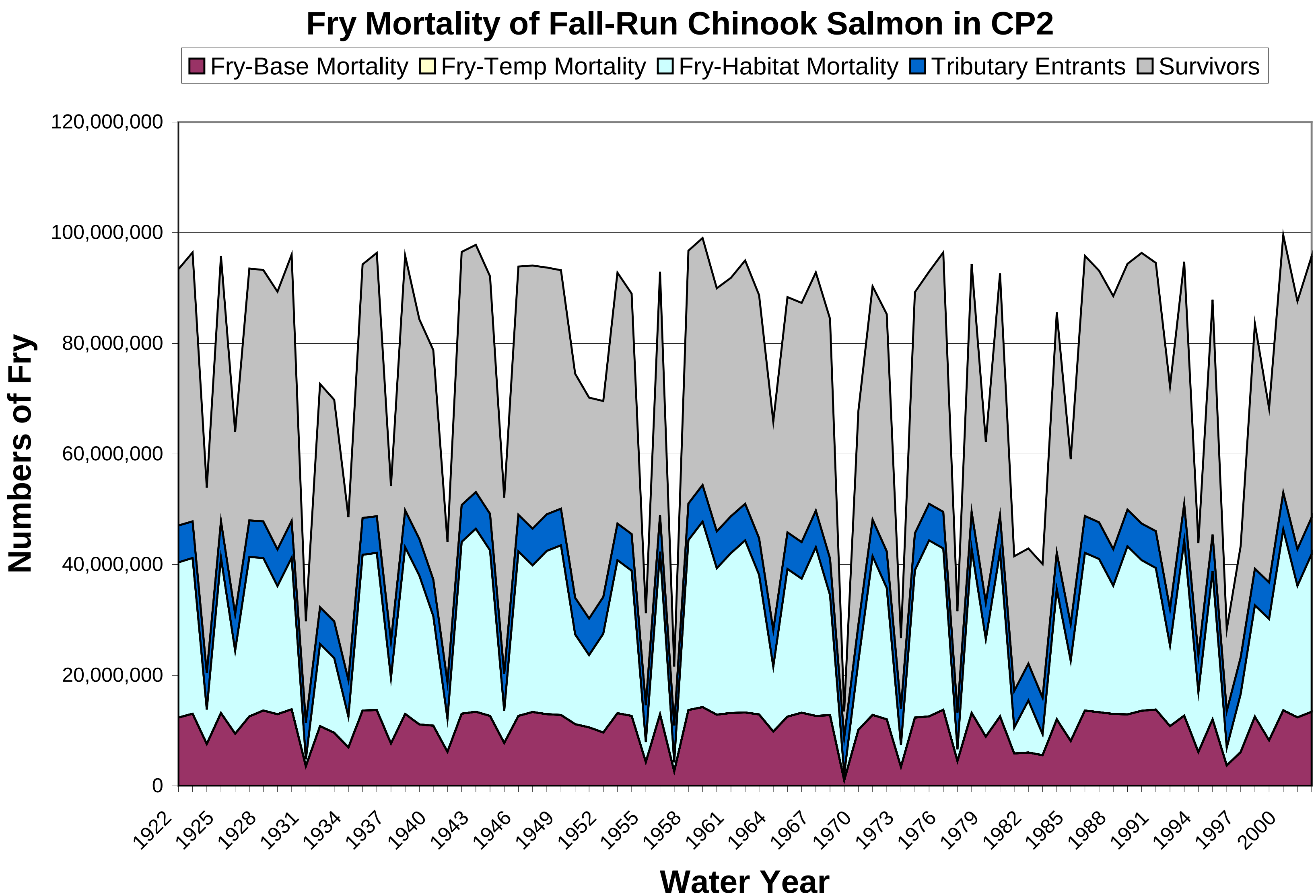

Figure B-38C. Source of mortality of fall-run Chinook salmon fry in CP2 based on the 1999 – 2006 population average.

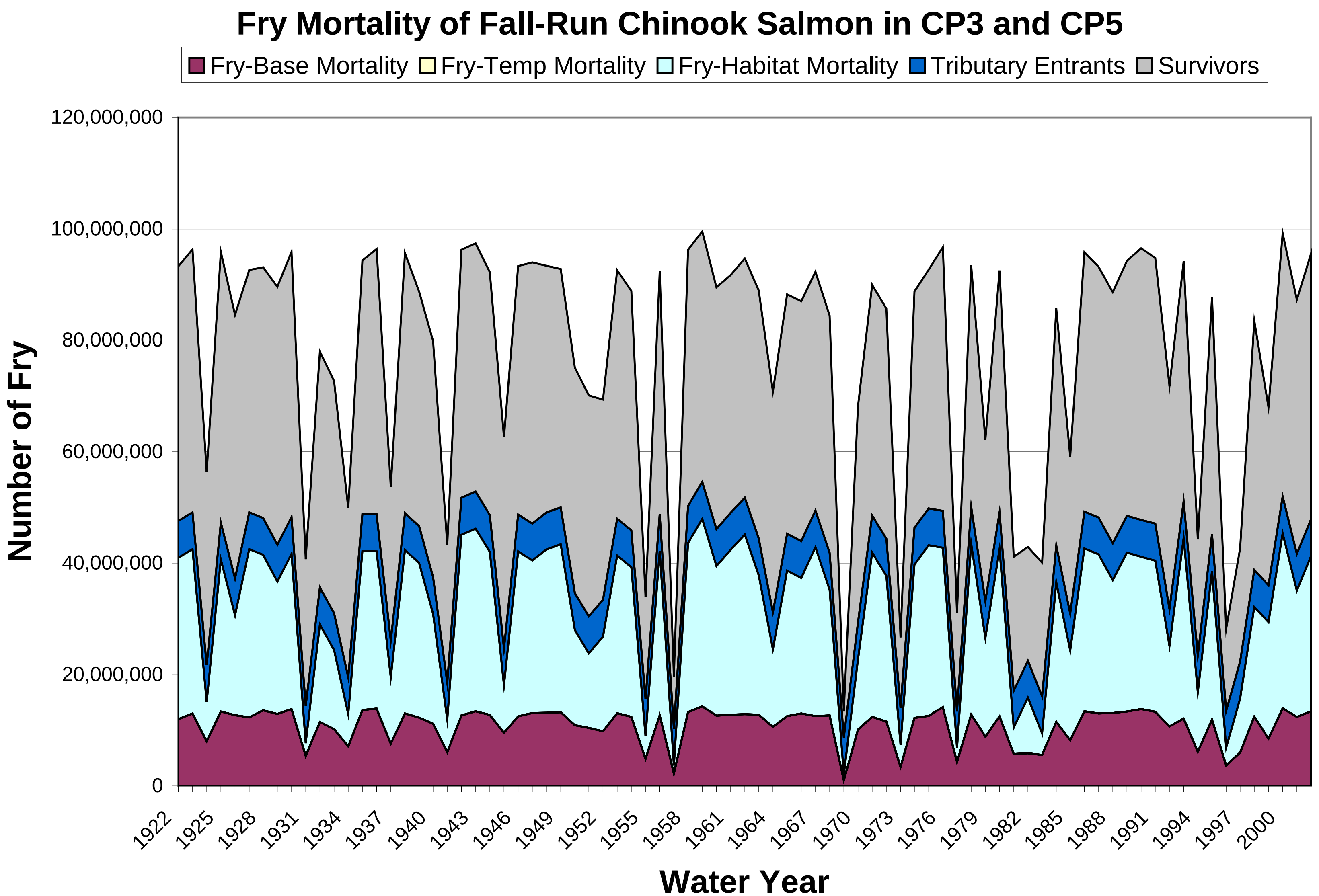

Figure B-38D. Source of mortality of fall-run Chinook salmon fry in CP3 and CP5 based on the 1999 – 2006 population average.

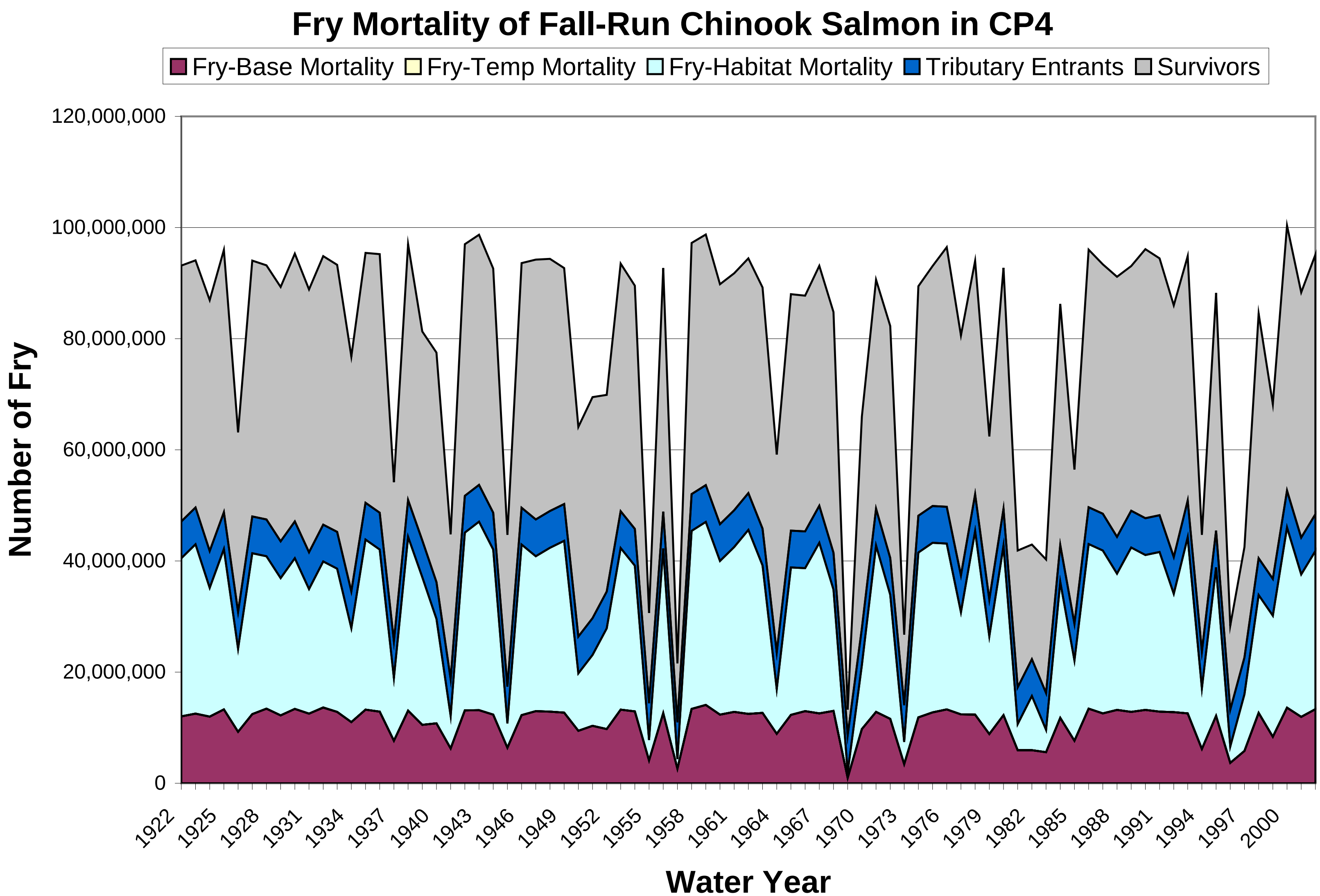

Figure B-38E. Source of mortality of fall-run Chinook salmon fry in CP4 based on the 1999 – 2006 population average.

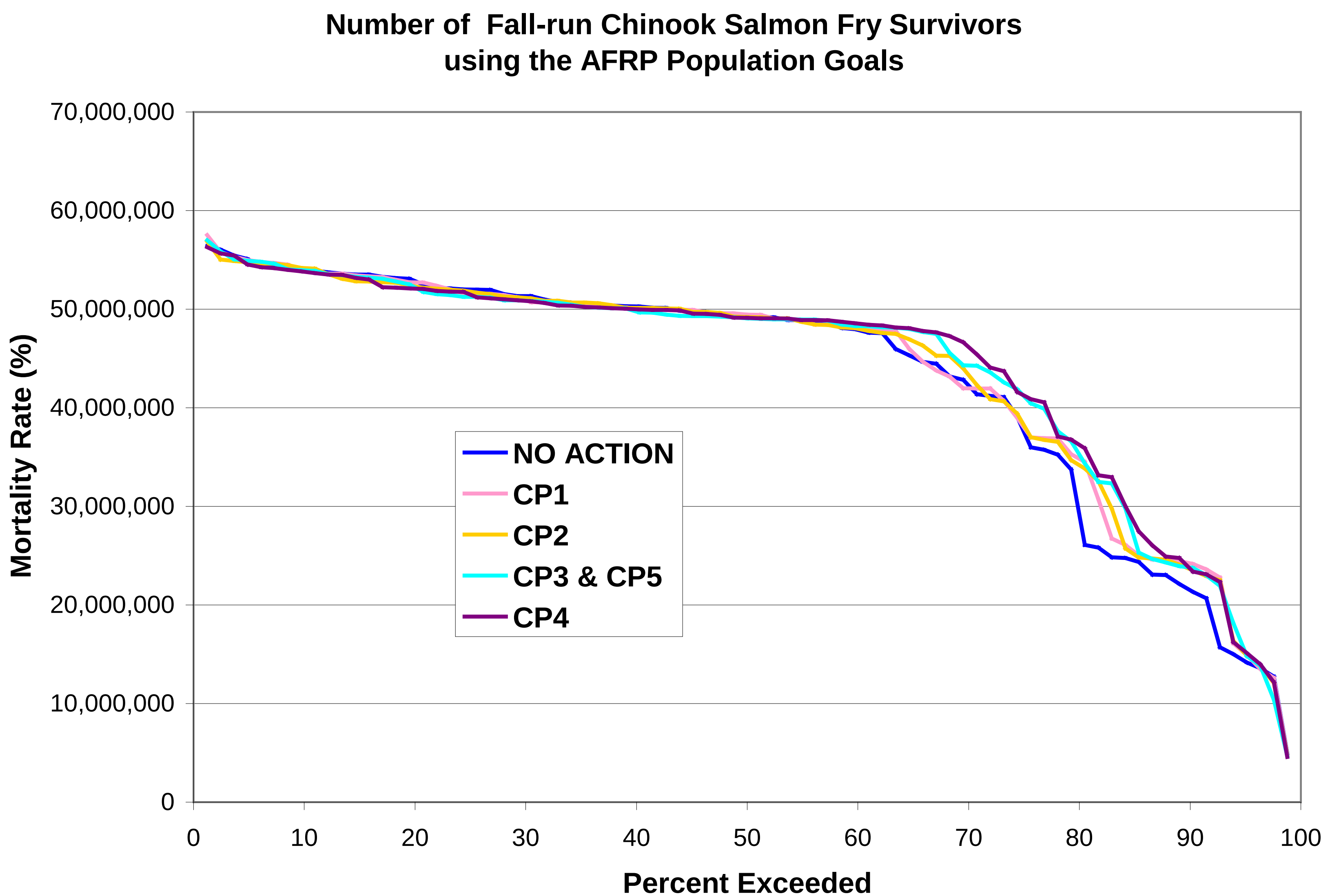

Figure B-39A. Frequency distribution of the number of fall-run Chinook salmon fry survivors during the 1921-2003 simulation period based on the AFRP population goals.

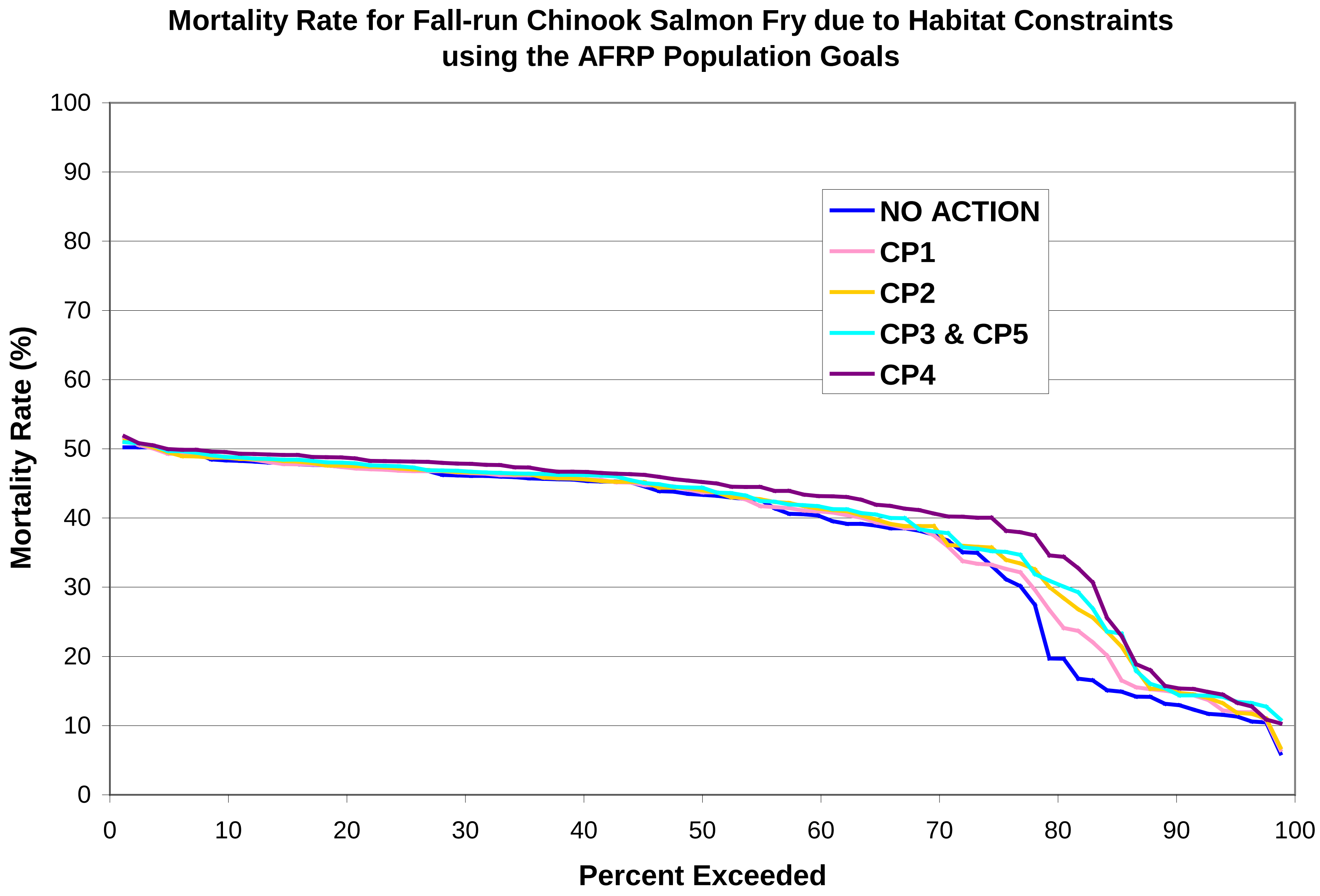

Figure B-39B. Frequency distribution of the mortality rate of fall-run Chinook salmon fry due to habitat constraints (forced movement of fry due to flows or fish density) during the 1921-2003 simulation period based on the AFRP population goals.

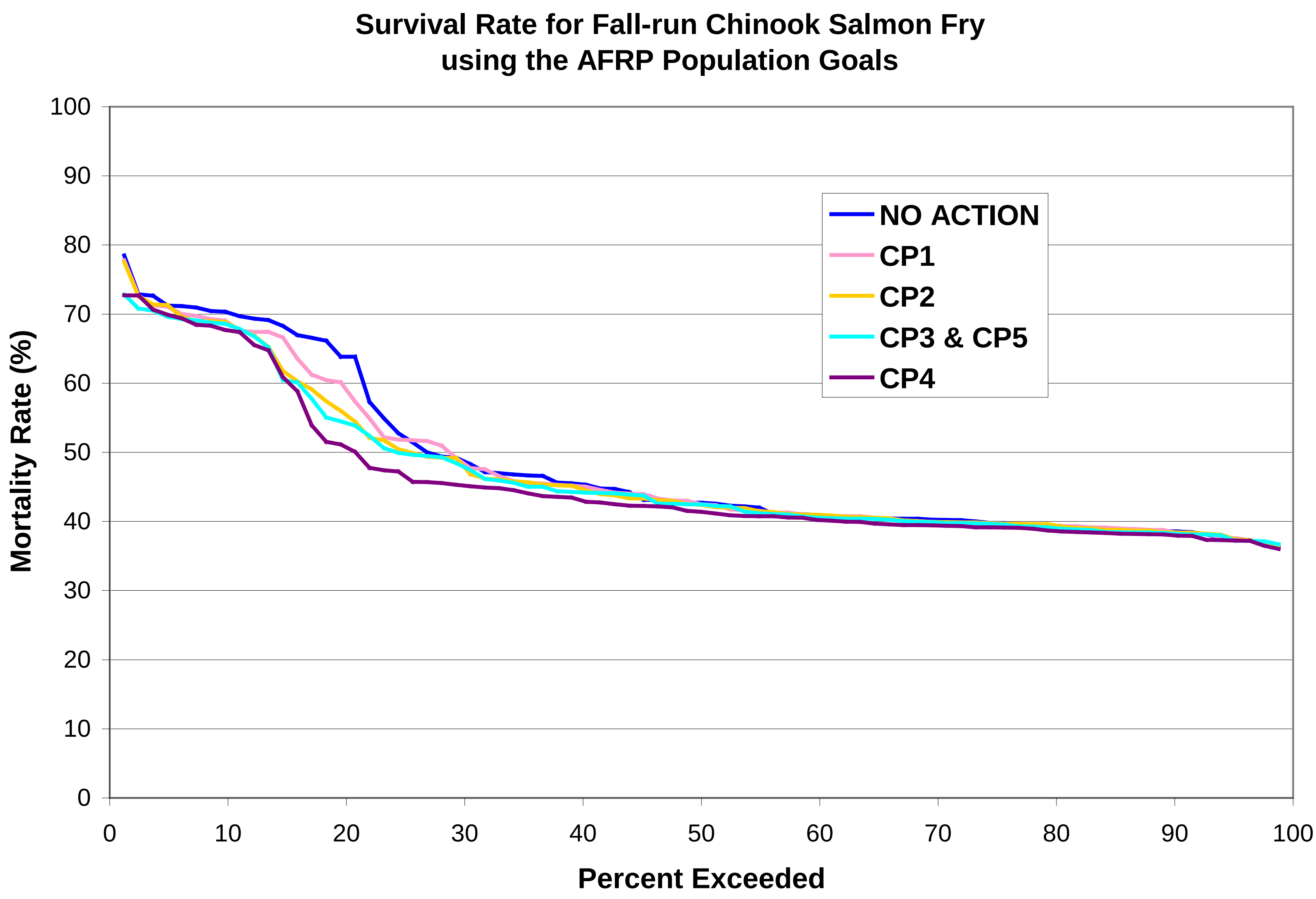

Figure B-39C. Frequency distribution of the survival rate of fall-run Chinook salmon fry during the 1921-2003 simulation period based on the AFRP population goals.

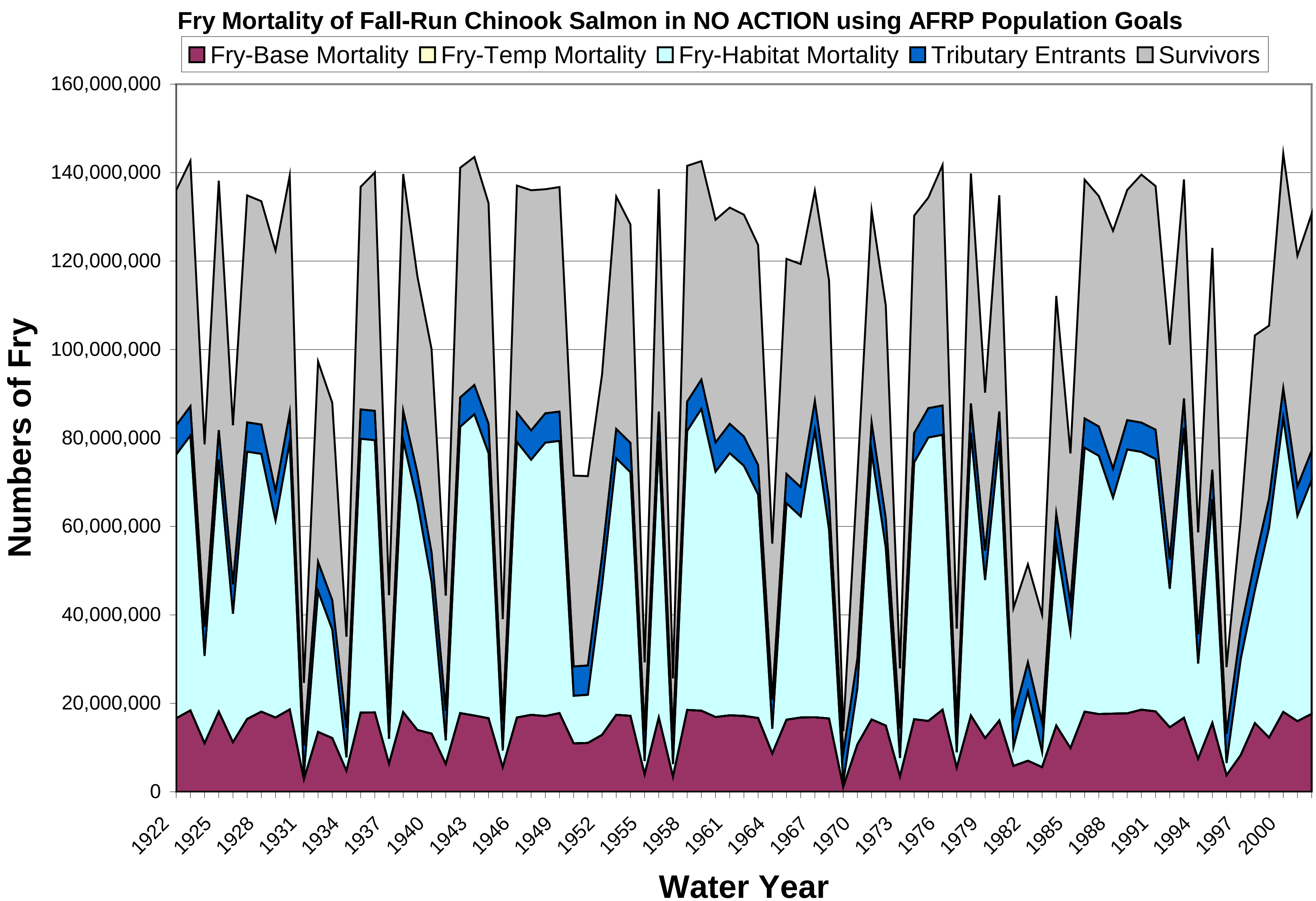

Figure B-40A. Source of mortality of fall-run Chinook salmon fry in NO ACTION based on the AFRP population goals.

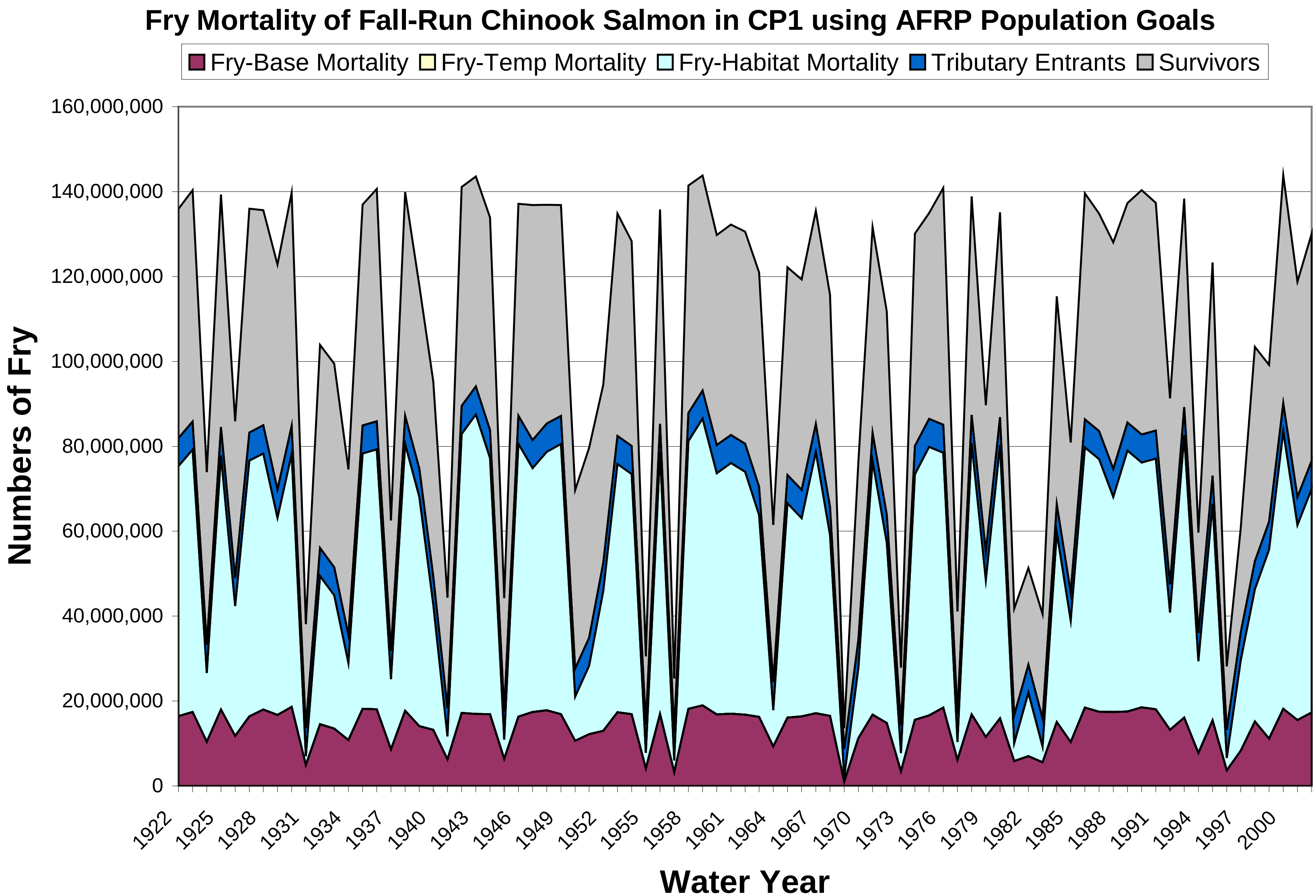

Figure B-40B. Source of mortality of fall-run Chinook salmon fry in CP1 based on the AFRP population goals.

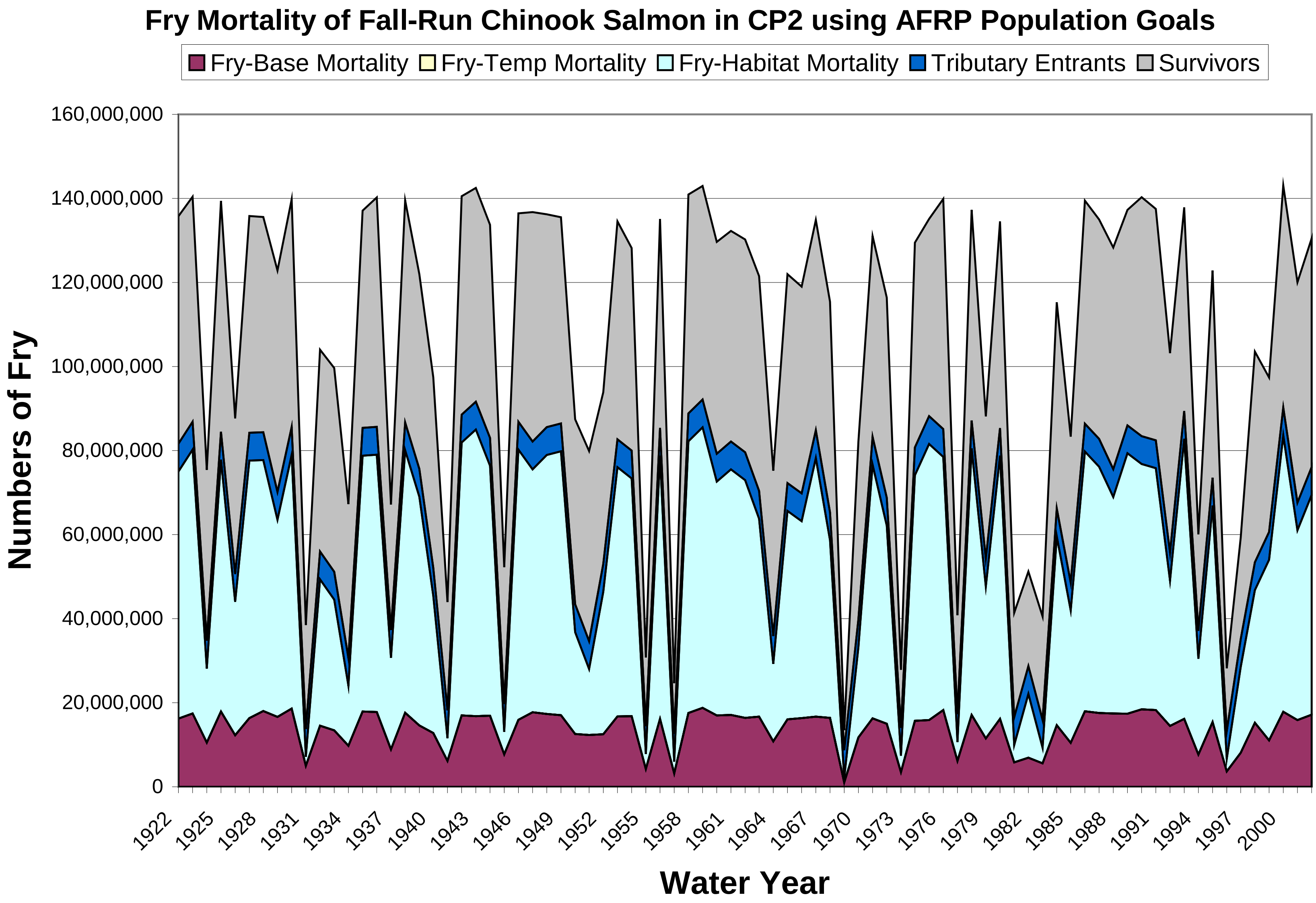

Figure B-40C. Source of mortality of fall-run Chinook salmon fry in CP2 based on the AFRP population goals.

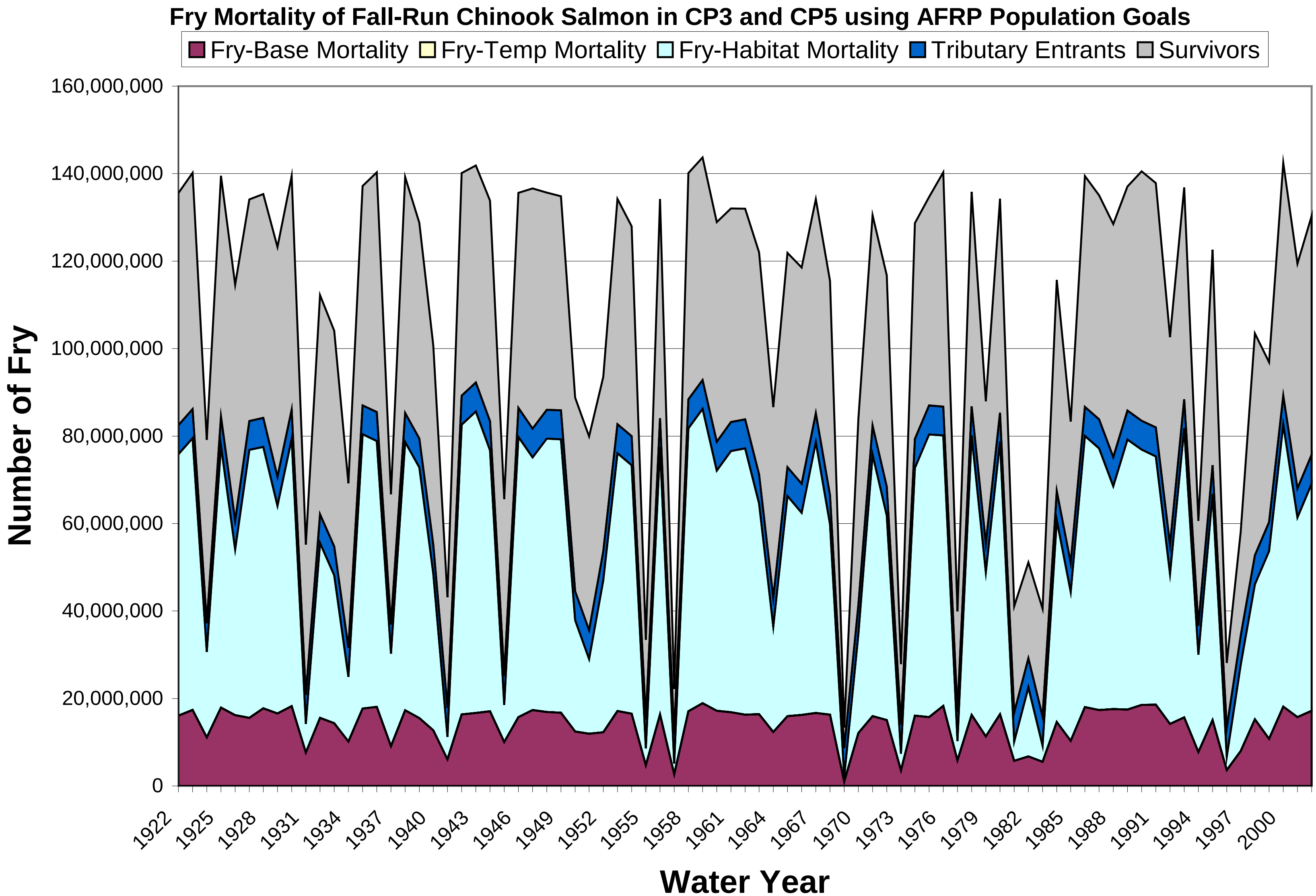

Figure B-40D. Source of mortality of fall-run Chinook salmon fry in CP3 and CP5 based on the AFRP population goals.

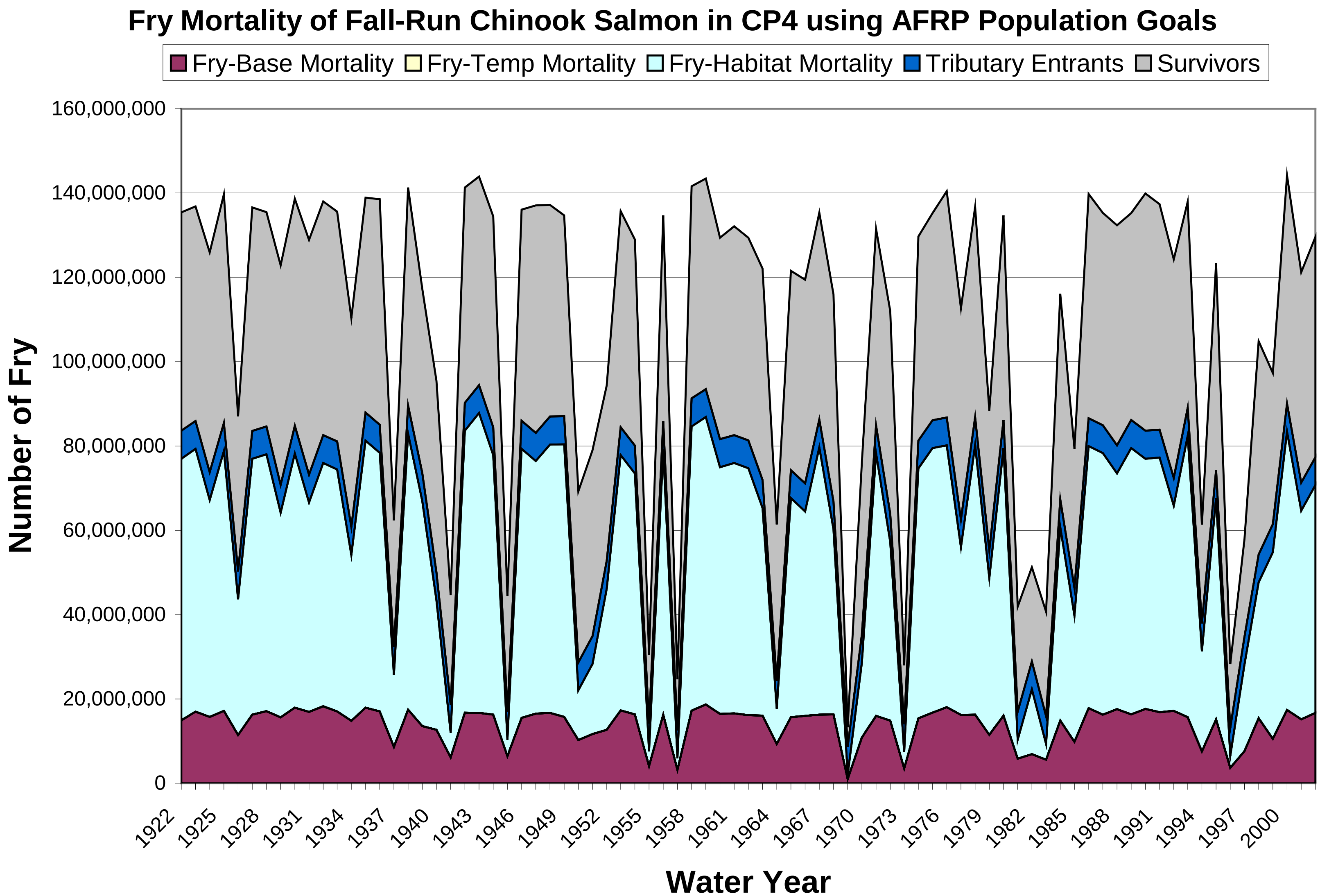

Figure B-40E. Source of mortality of fall-run Chinook salmon fry in CP4 based on the AFRP population goals.

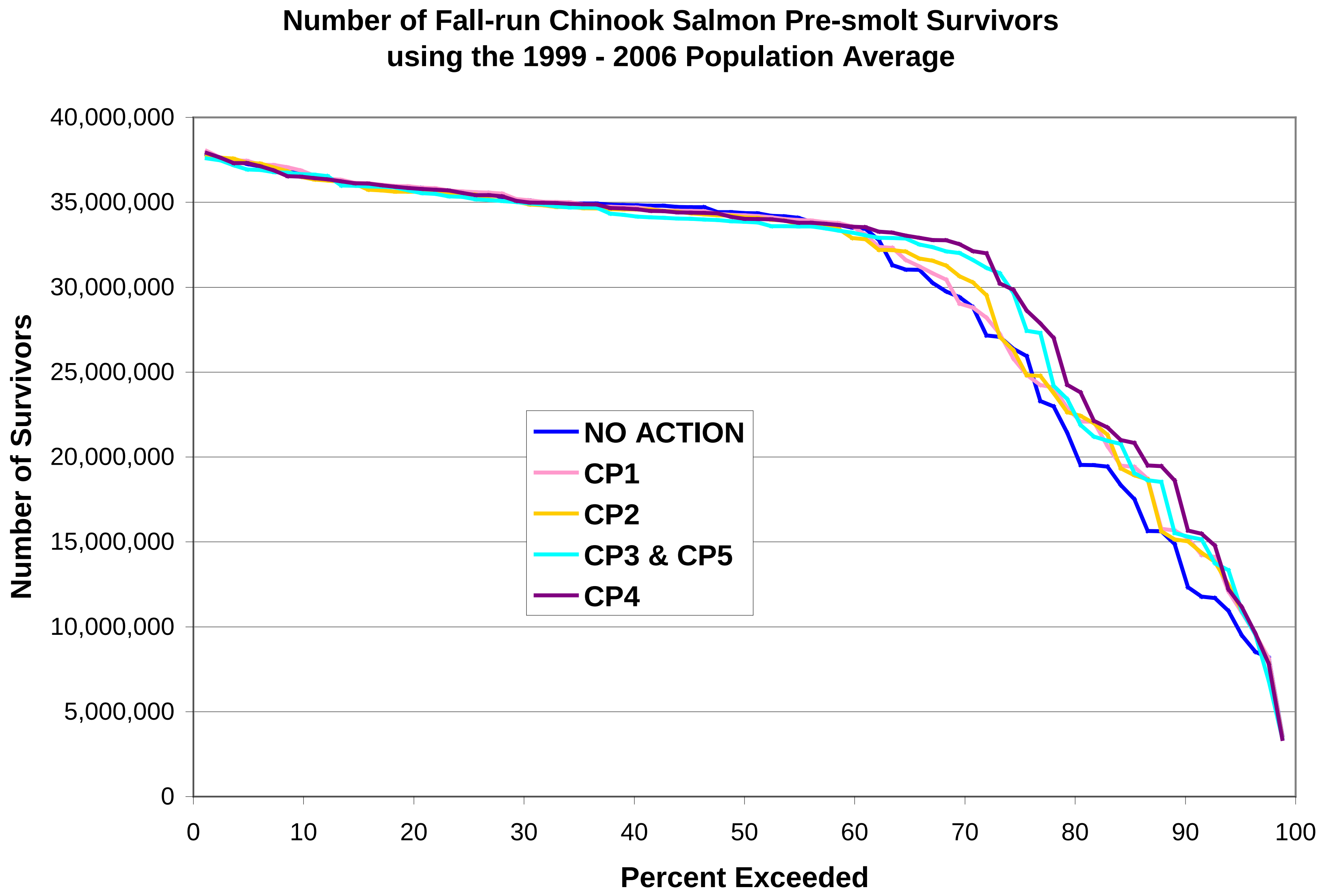

Figure B-41A. Frequency distribution of the number of fall-run Chinook salmon pre-smolt survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

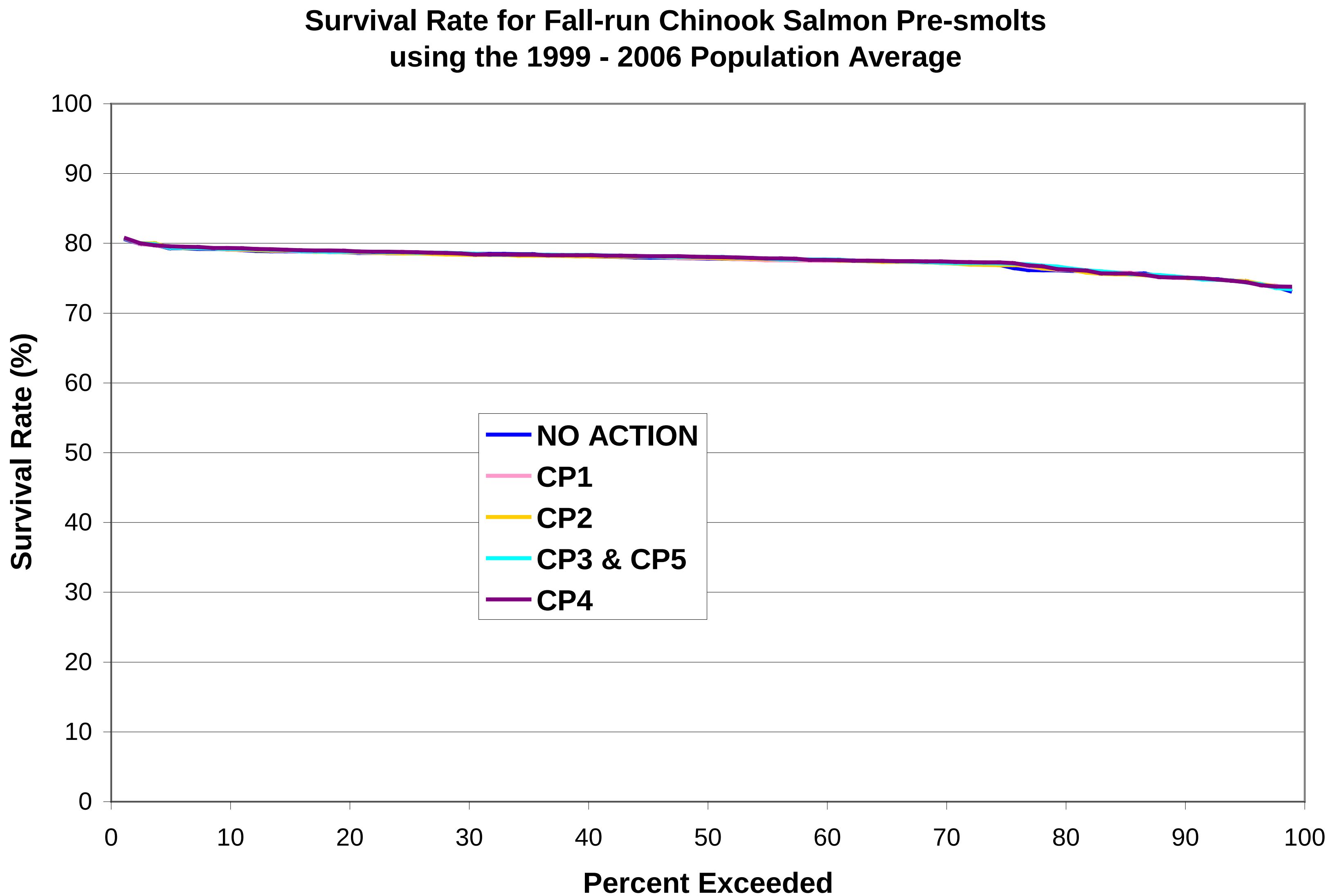

Figure B-41B. Frequency distribution of the survival rate of fall-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the 1999-2006 population average.

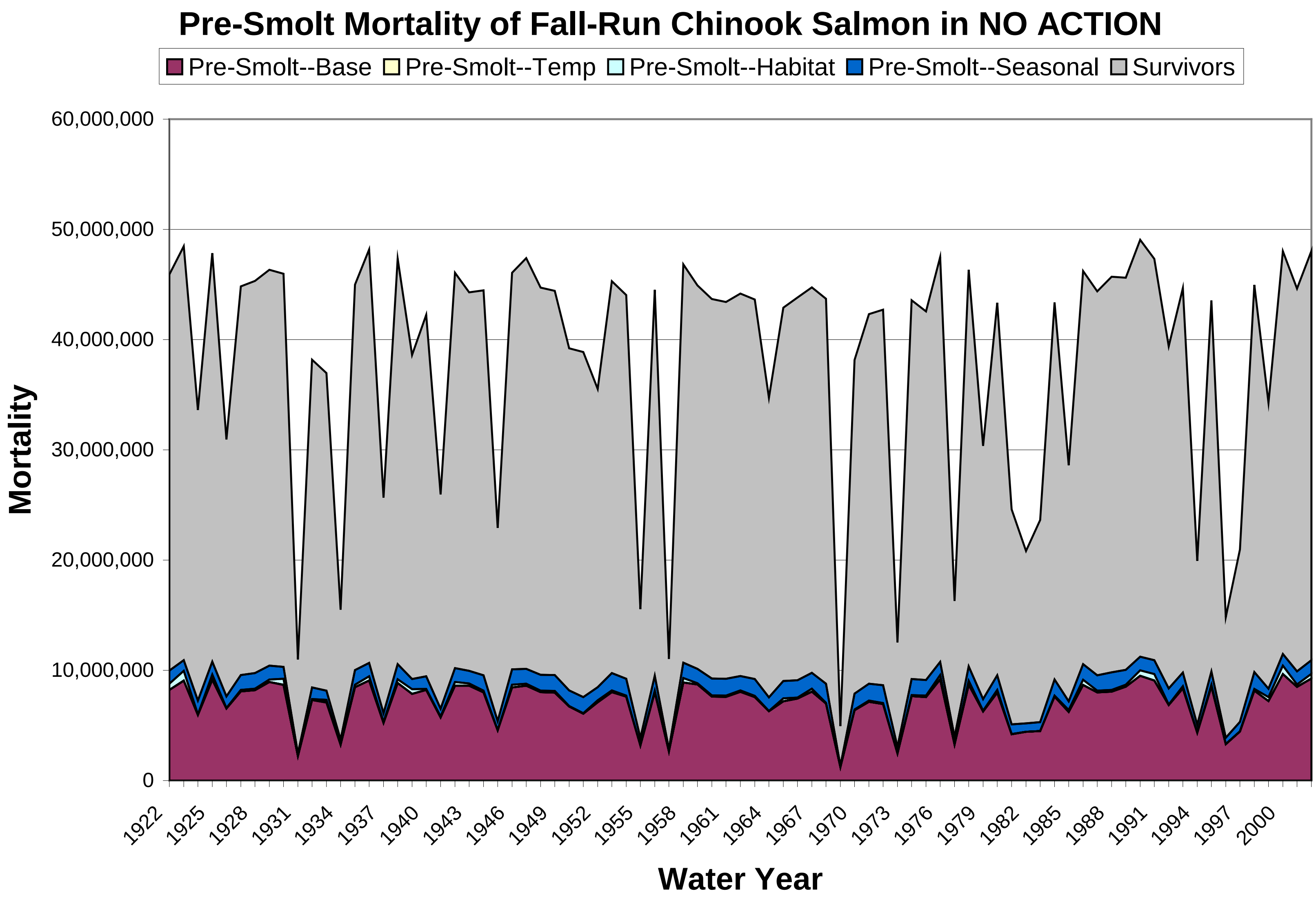

Figure B-42A. Source of mortality of fall-run Chinook salmon pre-smolts in NO ACTION based on the 1999-2006 population average.

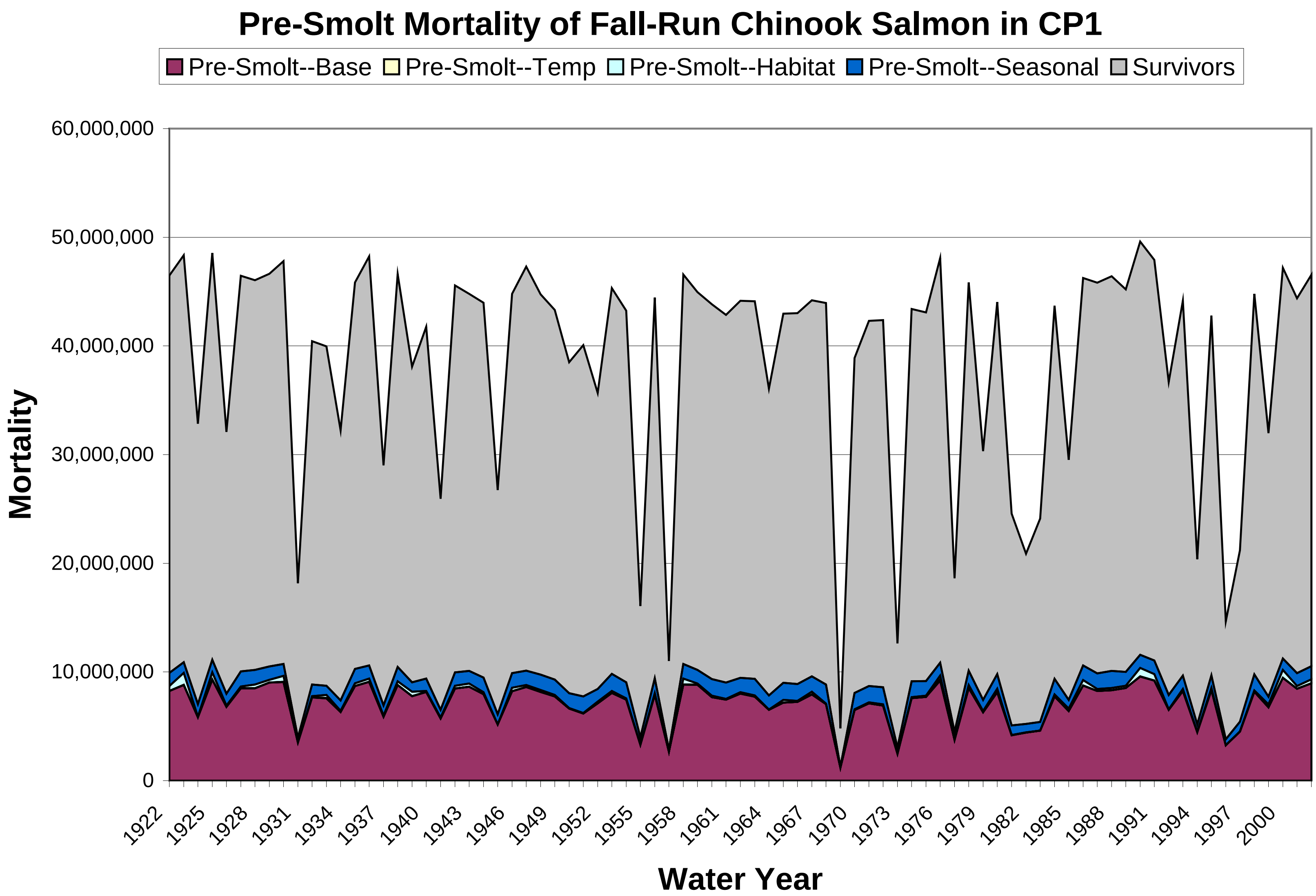

Figure B-42B. Source of mortality of fall-run Chinook salmon pre-smolts in CP1 based on the 1999-2006 population average.

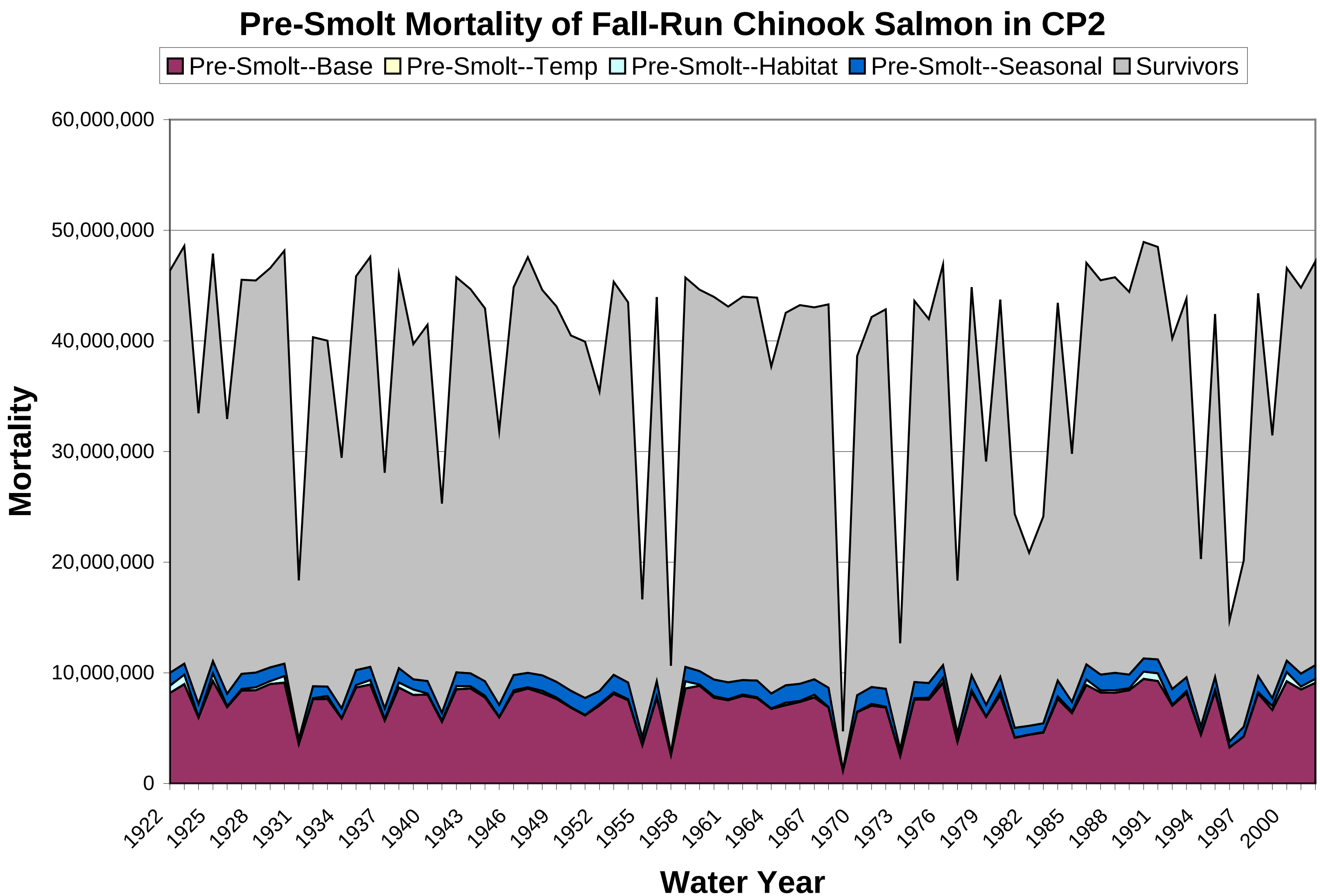

Figure B-42C. Source of mortality of fall-run Chinook salmon pre-smolts in CP2 based on the 1999-2006 population average.

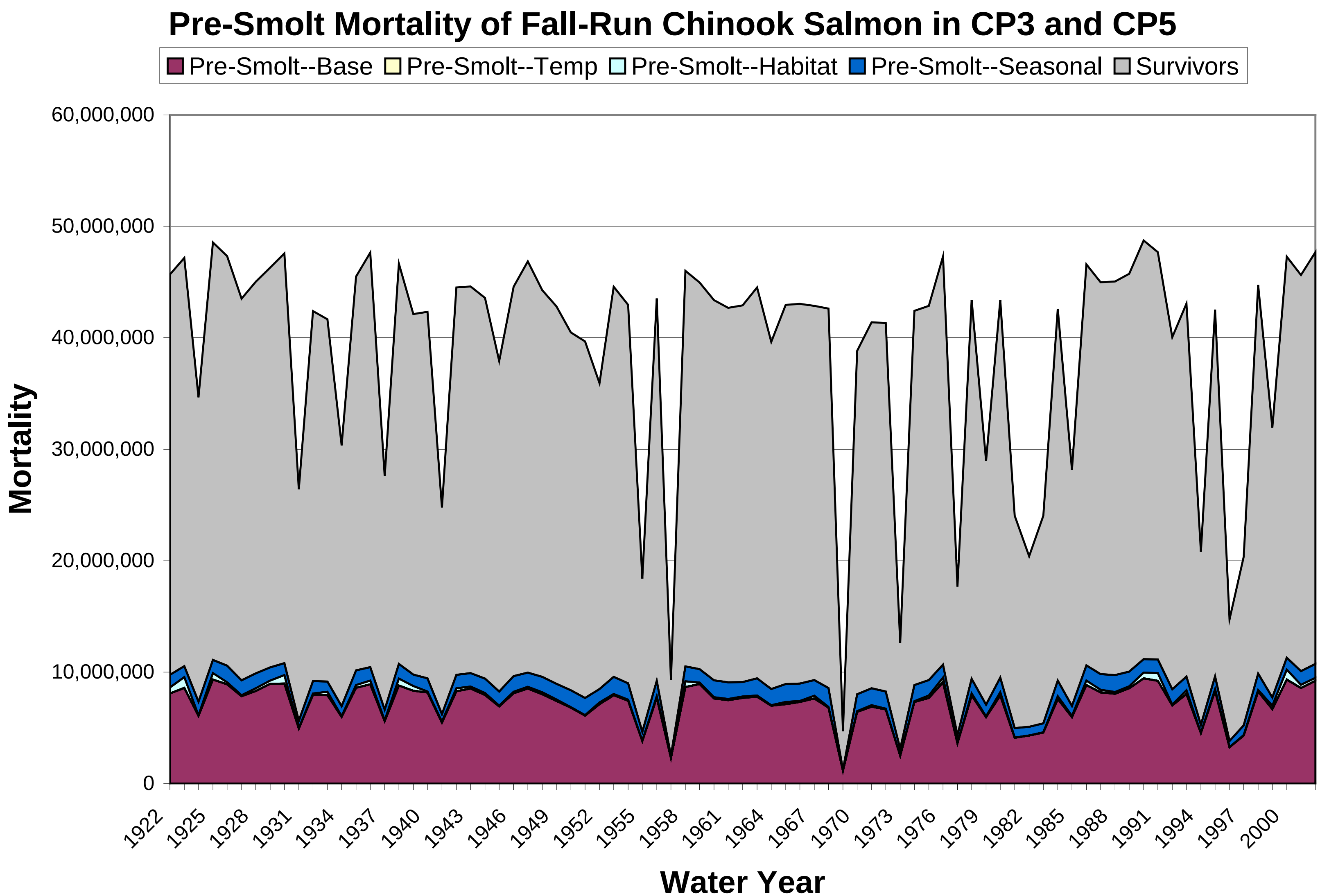

Figure B-42D. Source of mortality of fall-run Chinook salmon pre-smolts in CP3 and CP5 based on the 1999-2006 population average.

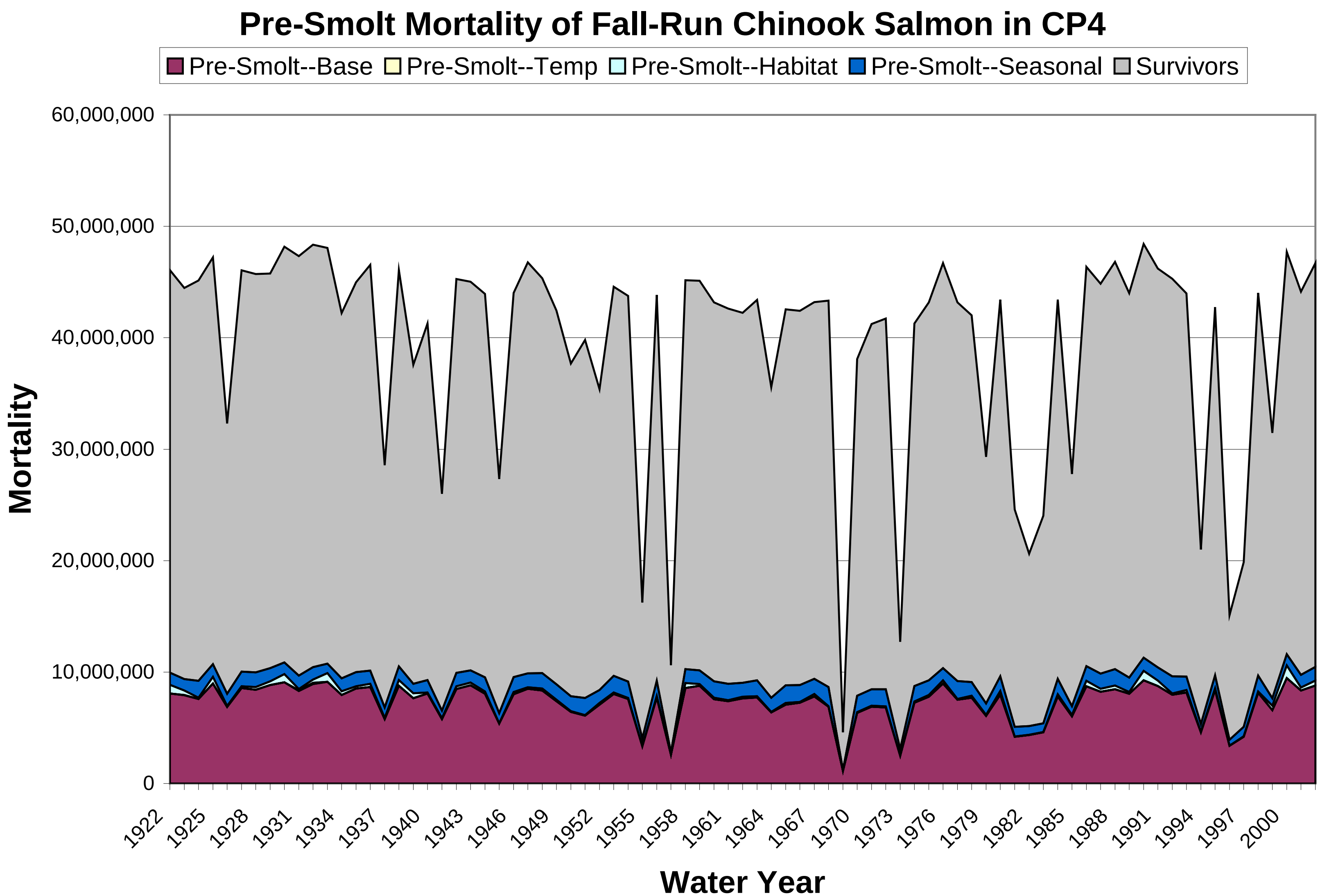

Figure B-42E. Source of mortality of fall-run Chinook salmon pre-smolts in CP4 based on the 1999-2006 population average.

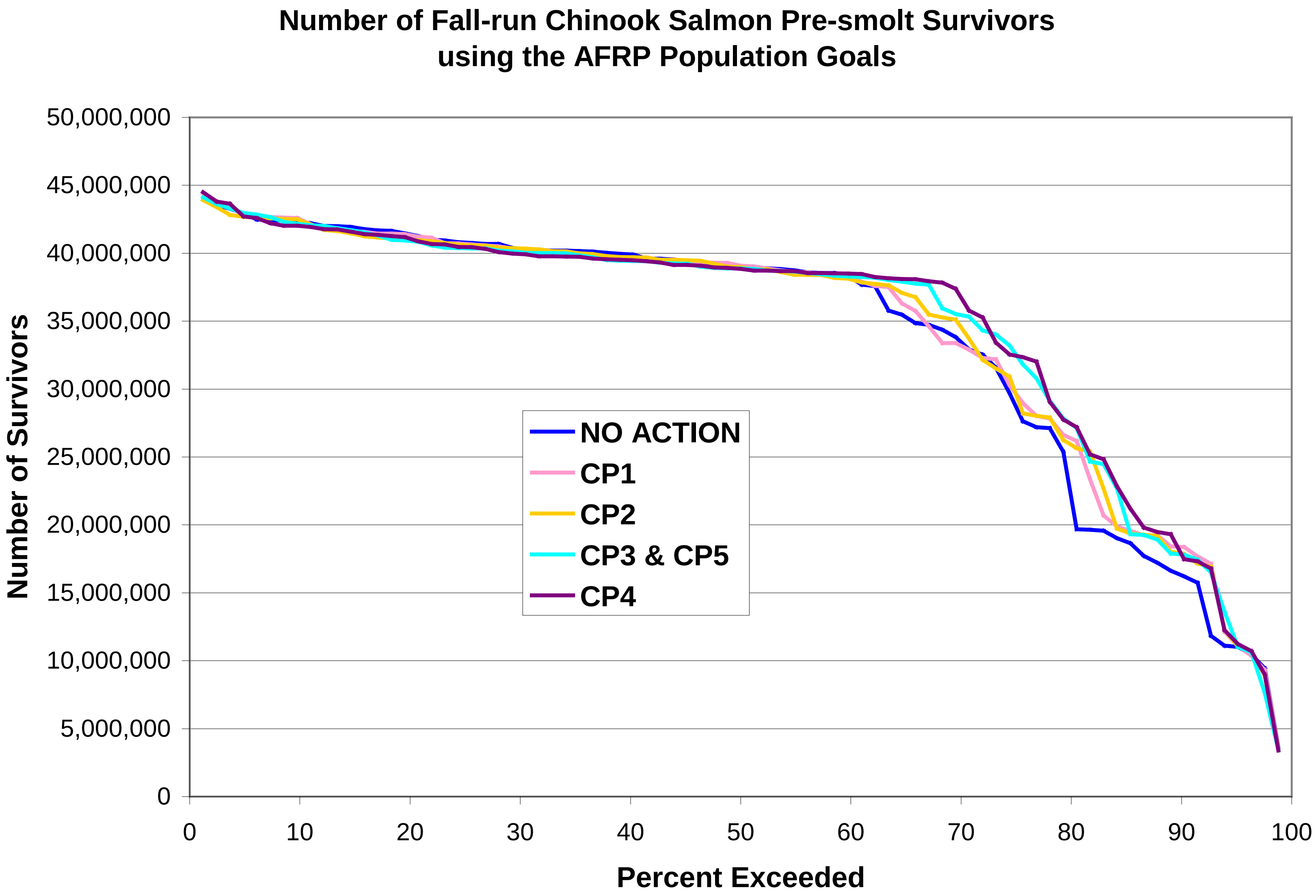

Figure B-43A. Frequency distribution of the number of fall-run Chinook salmon pre-smolt survivors during the 1921-2003 simulation period based on the AFRP population goals.

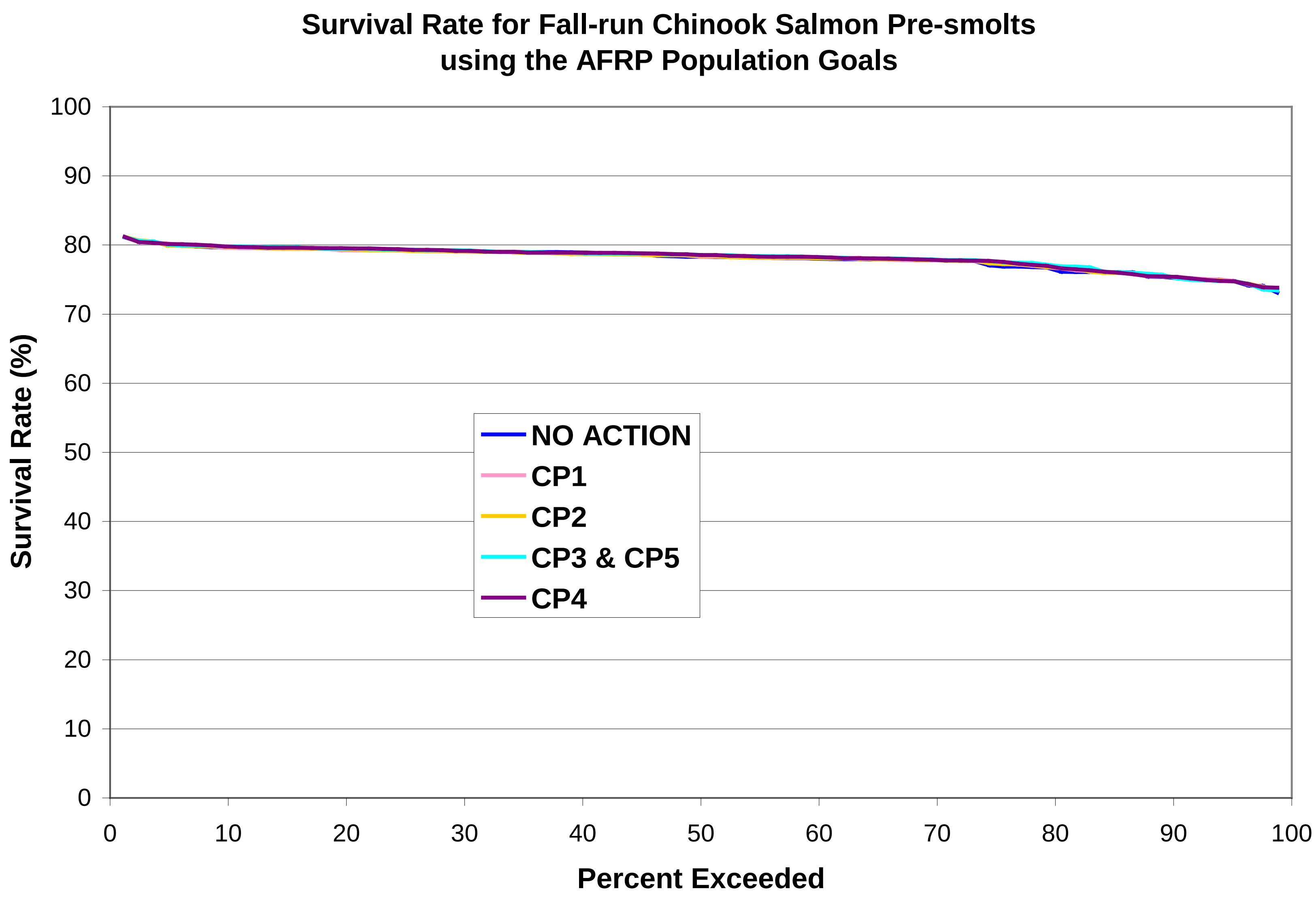

Figure B-43B. Frequency distribution of the survival rate of fall-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the AFRP population goals.

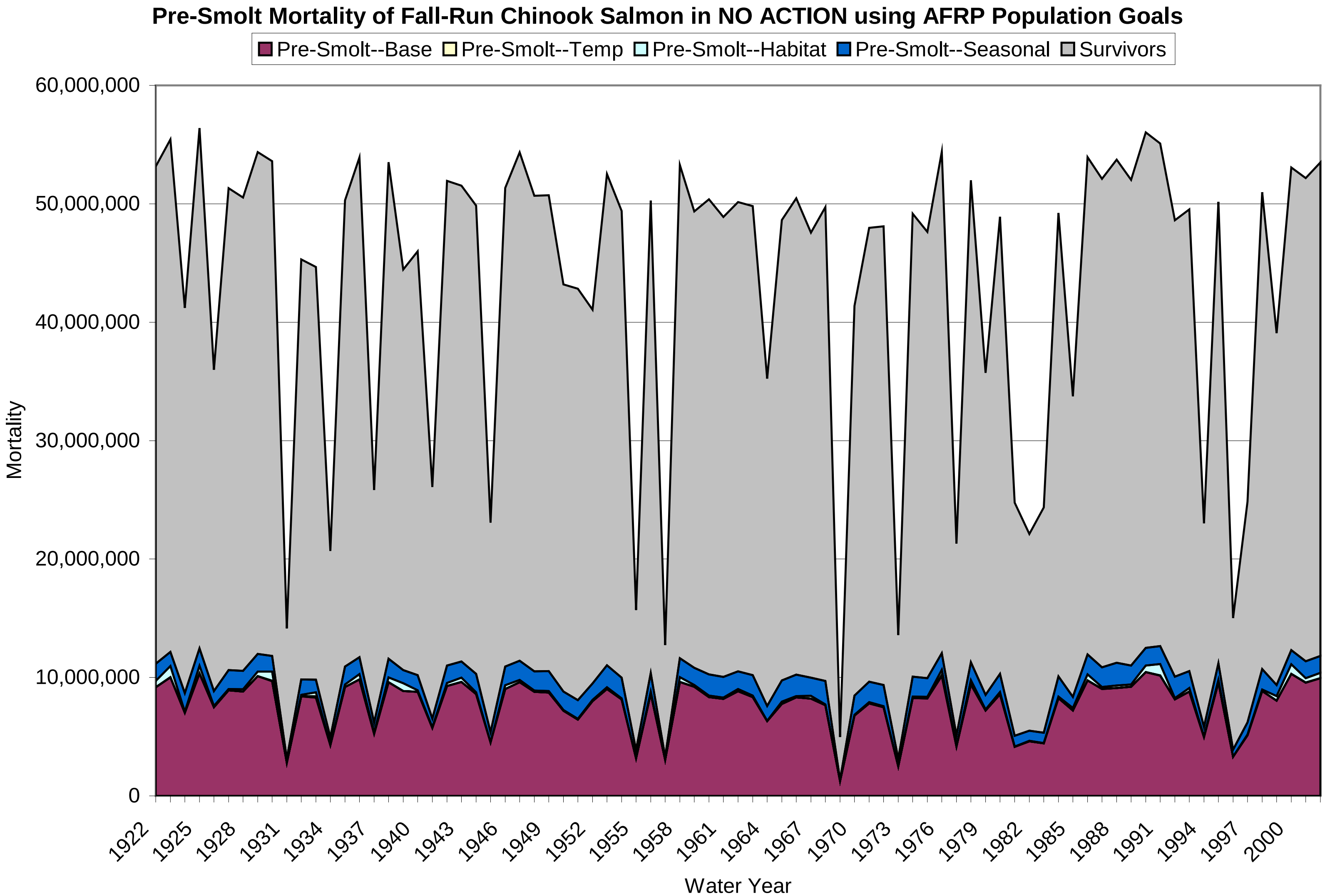

Figure B-44A. Source of mortality of fall-run Chinook salmon pre-smolts in NO ACTION based on the AFRP population goals.

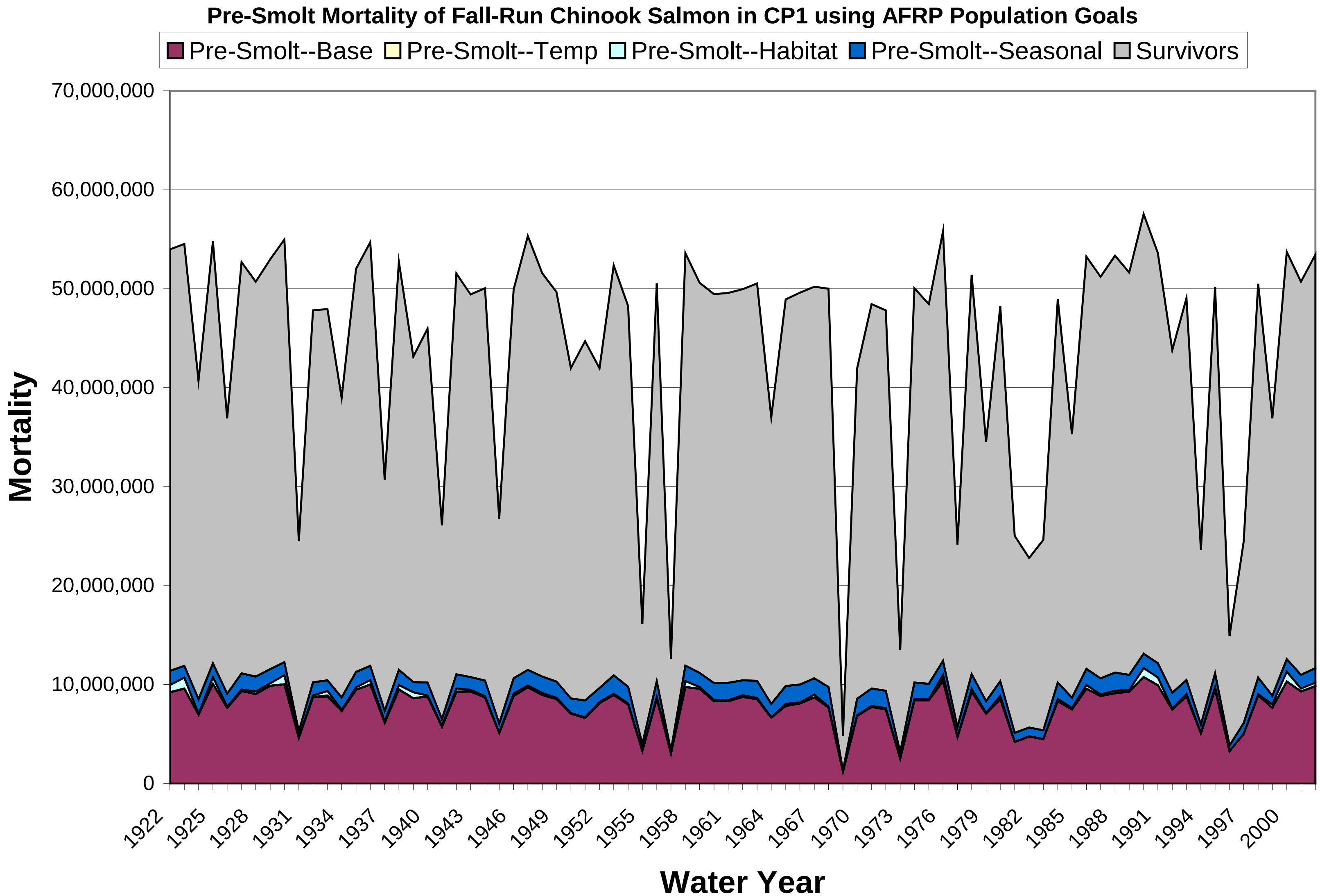

Figure B-44B. Source of mortality of fall-run Chinook salmon pre-smolts in CP1 based on the AFRP population goals.

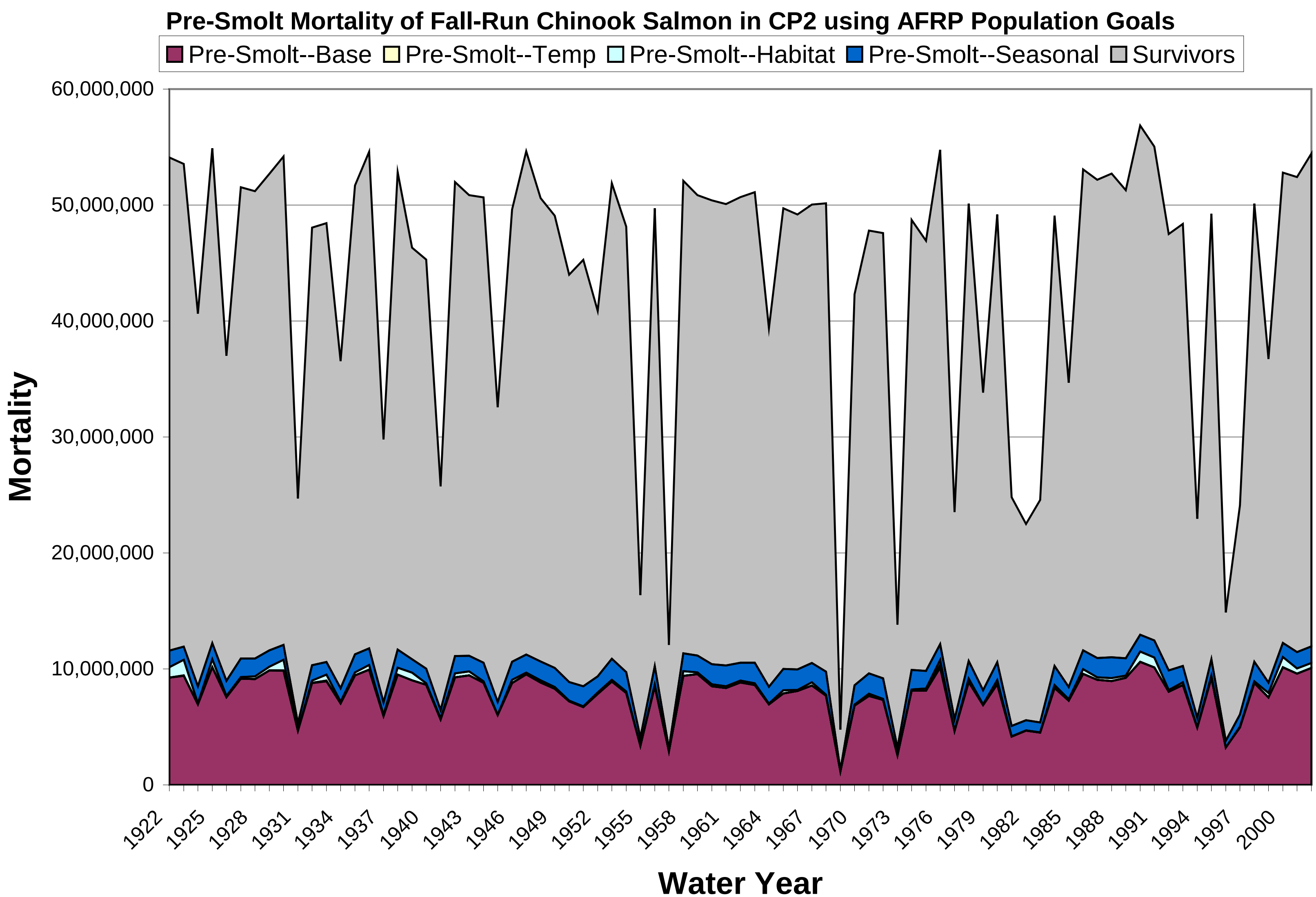

Figure B-44C. Source of mortality of fall-run Chinook salmon pre-smolts in CP2 based on the AFRP population goals.

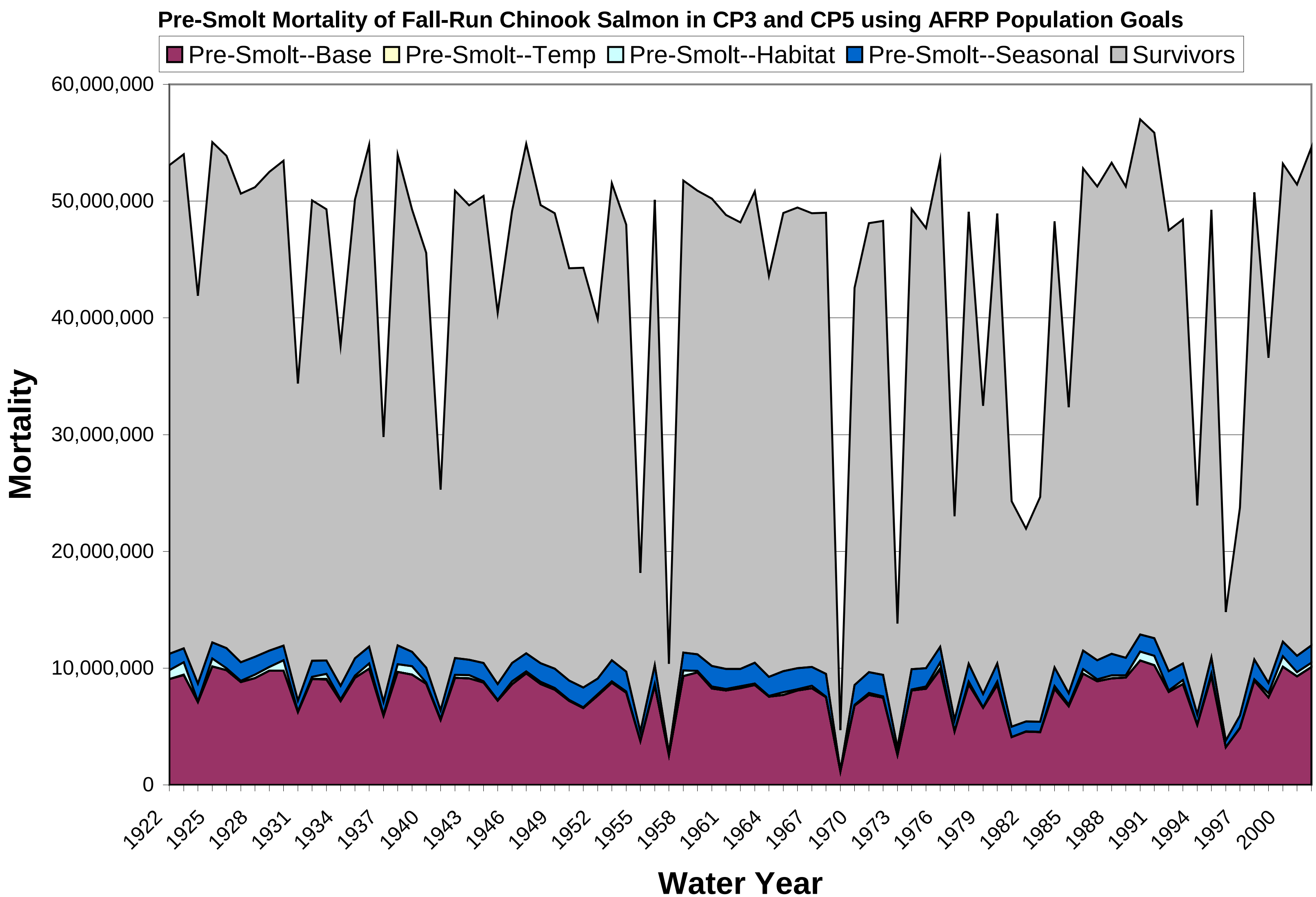

Figure B-44D. Source of mortality of fall-run Chinook salmon pre-smolts in CP3 and CP5 based on the AFRP population goals.

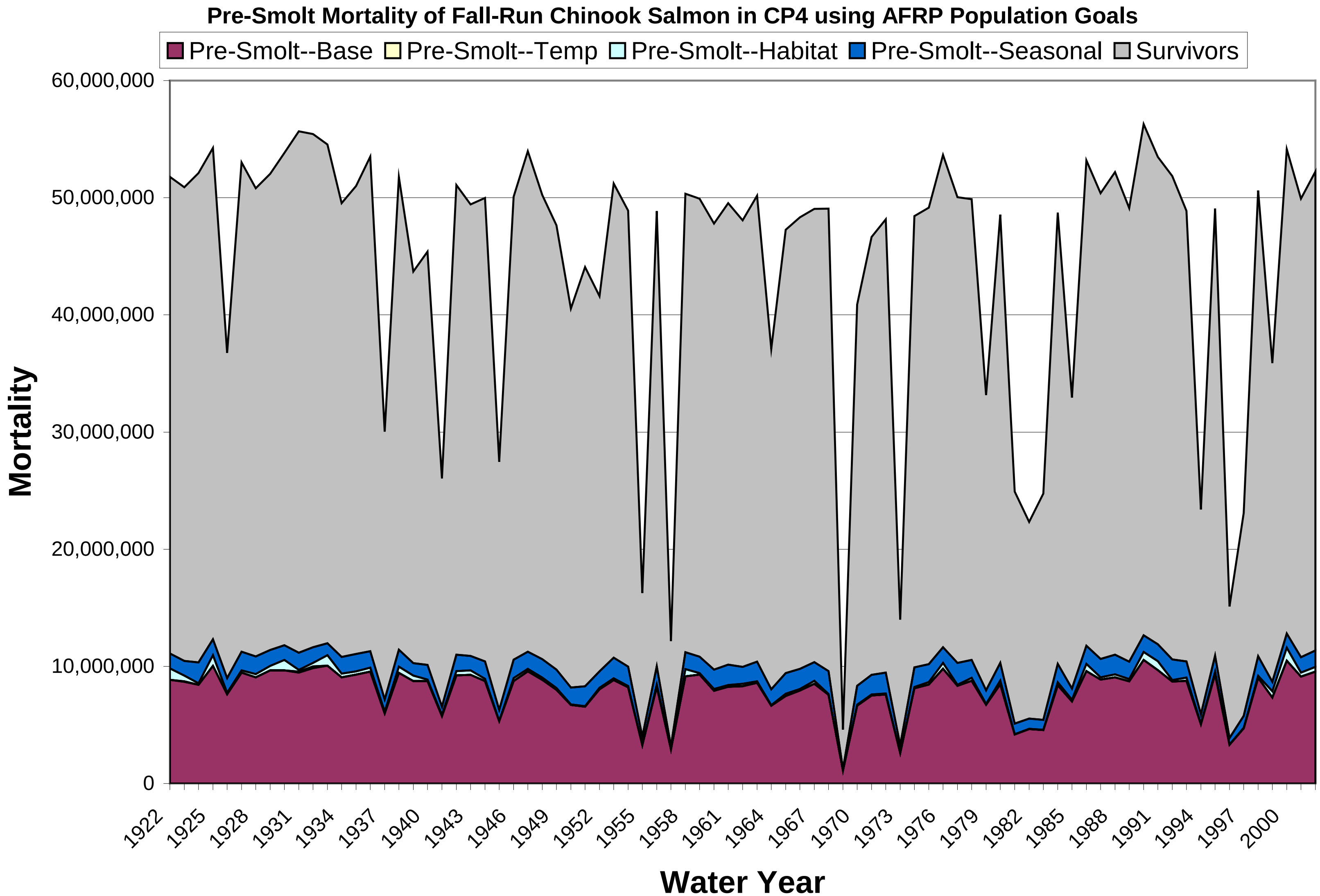

Figure B-44E. Source of mortality of fall-run Chinook salmon pre-smolts in CP4 based on the AFRP population goals.

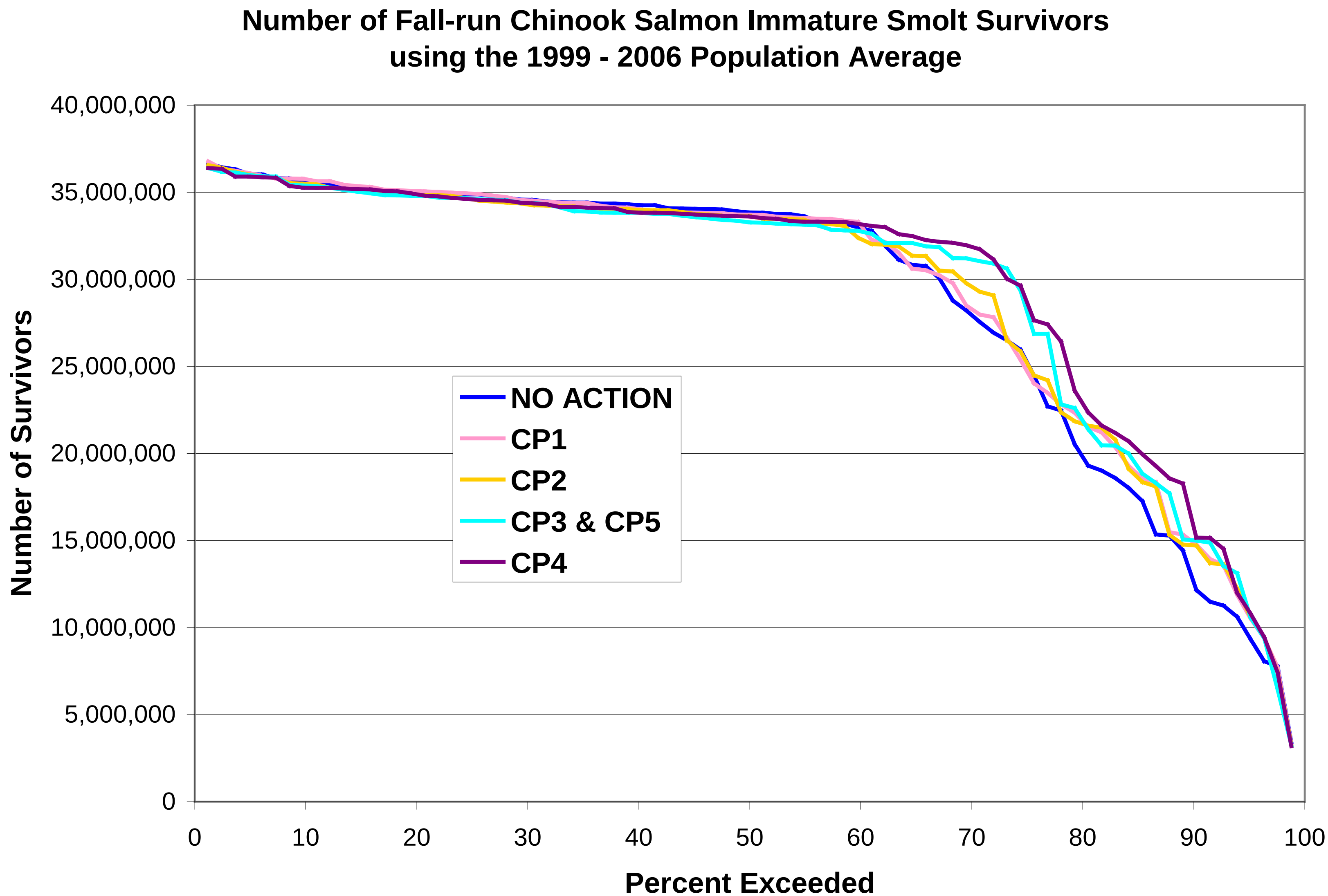

Figure B-45A. Frequency distribution of the number of fall-run Chinook salmon immature smolt survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

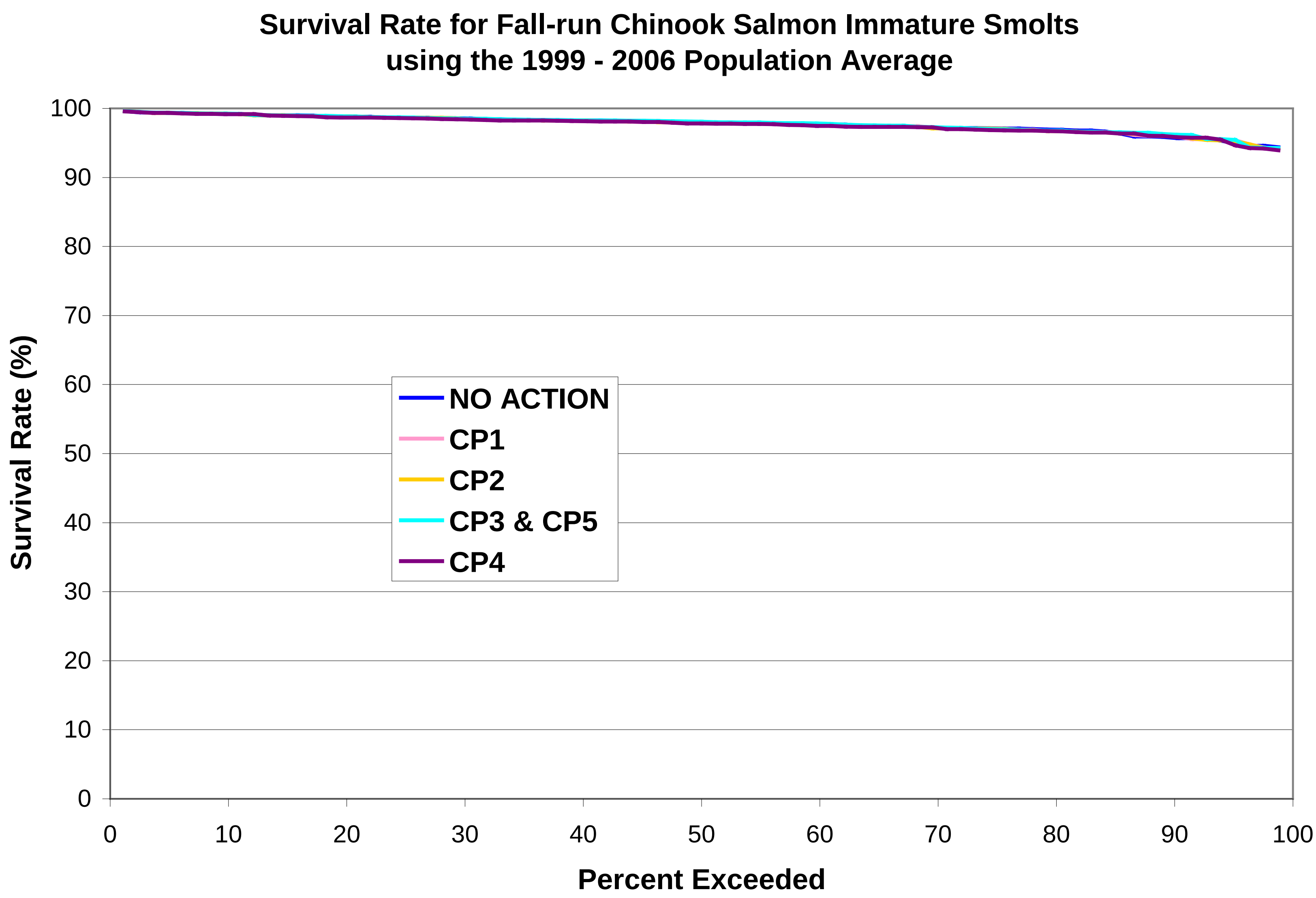

Figure B-45B. Frequency distribution of the survival rate of fall-run Chinook salmon immature smolts during the 1921-2003 simulation period based on the 1999-2006 population average.

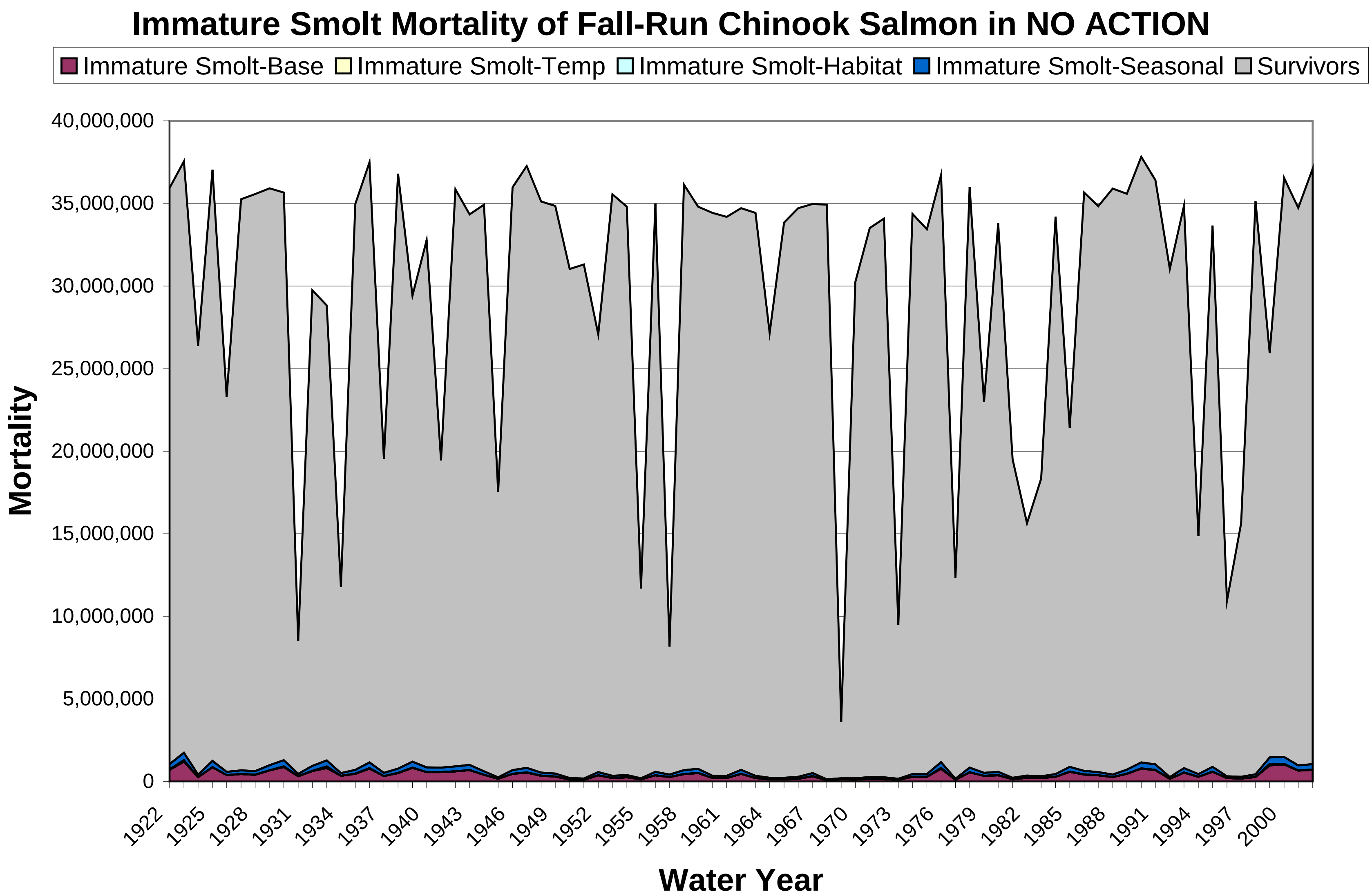

Figure B-46A. Source of mortality of fall-run Chinook salmon immature smolts in NO ACTION based on the 1999-2006 population average.

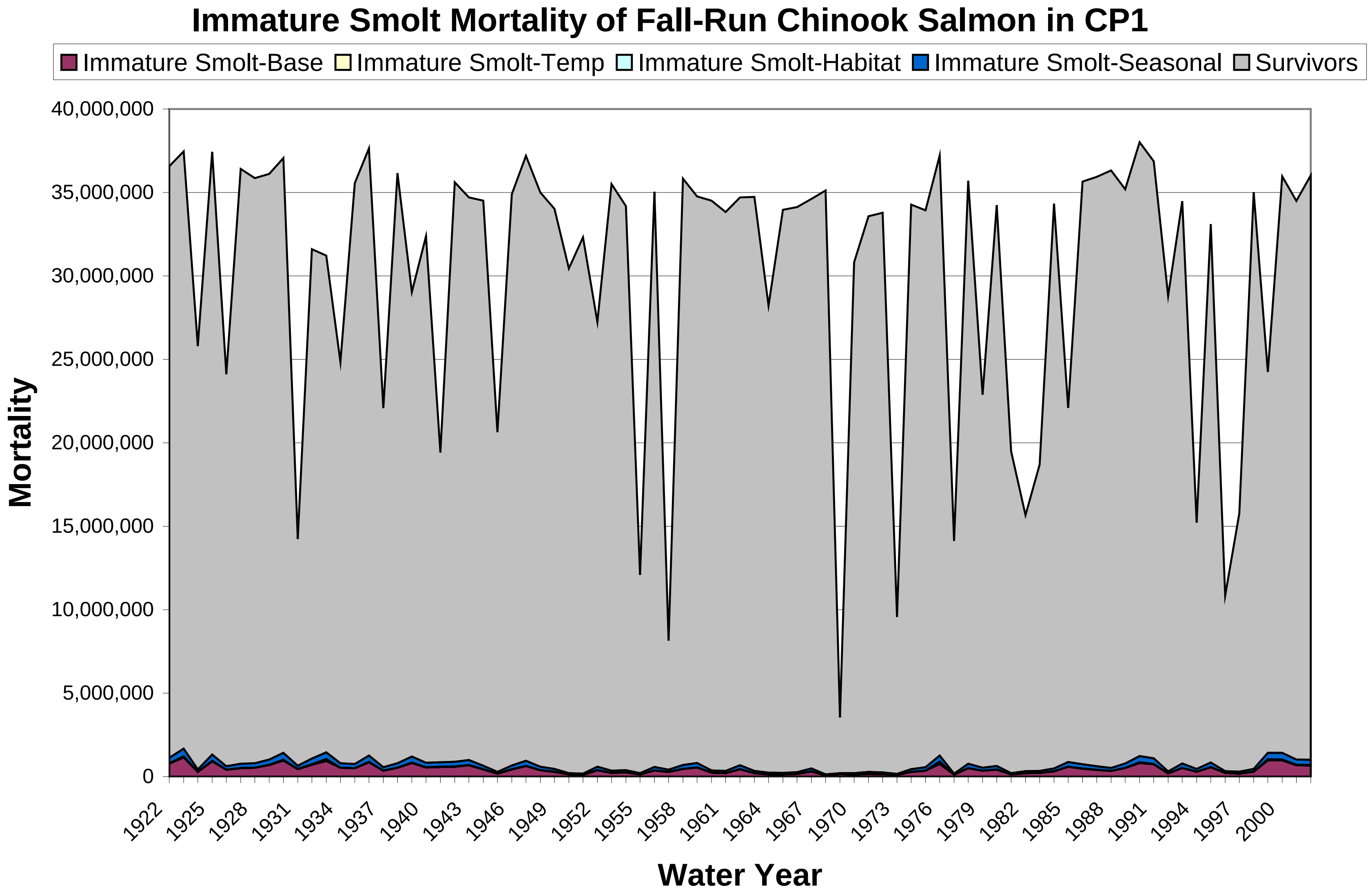

Figure B-46B. Source of mortality of fall-run Chinook salmon immature smolts in CP1 based on the 1999-2006 population average.

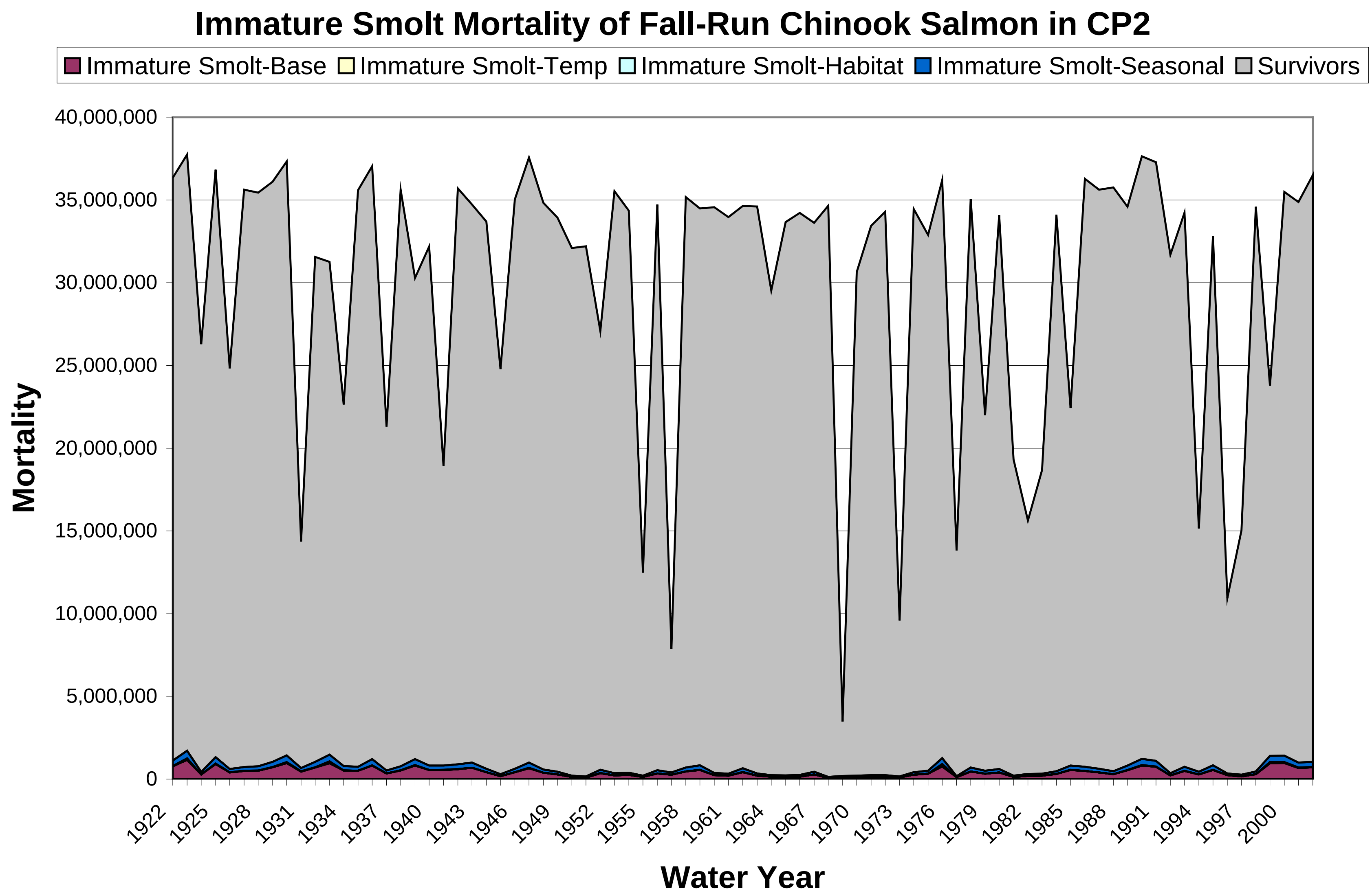

Figure B-46C. Source of mortality of fall-run Chinook salmon immature smolts in CP2 based on the 1999-2006 population average.

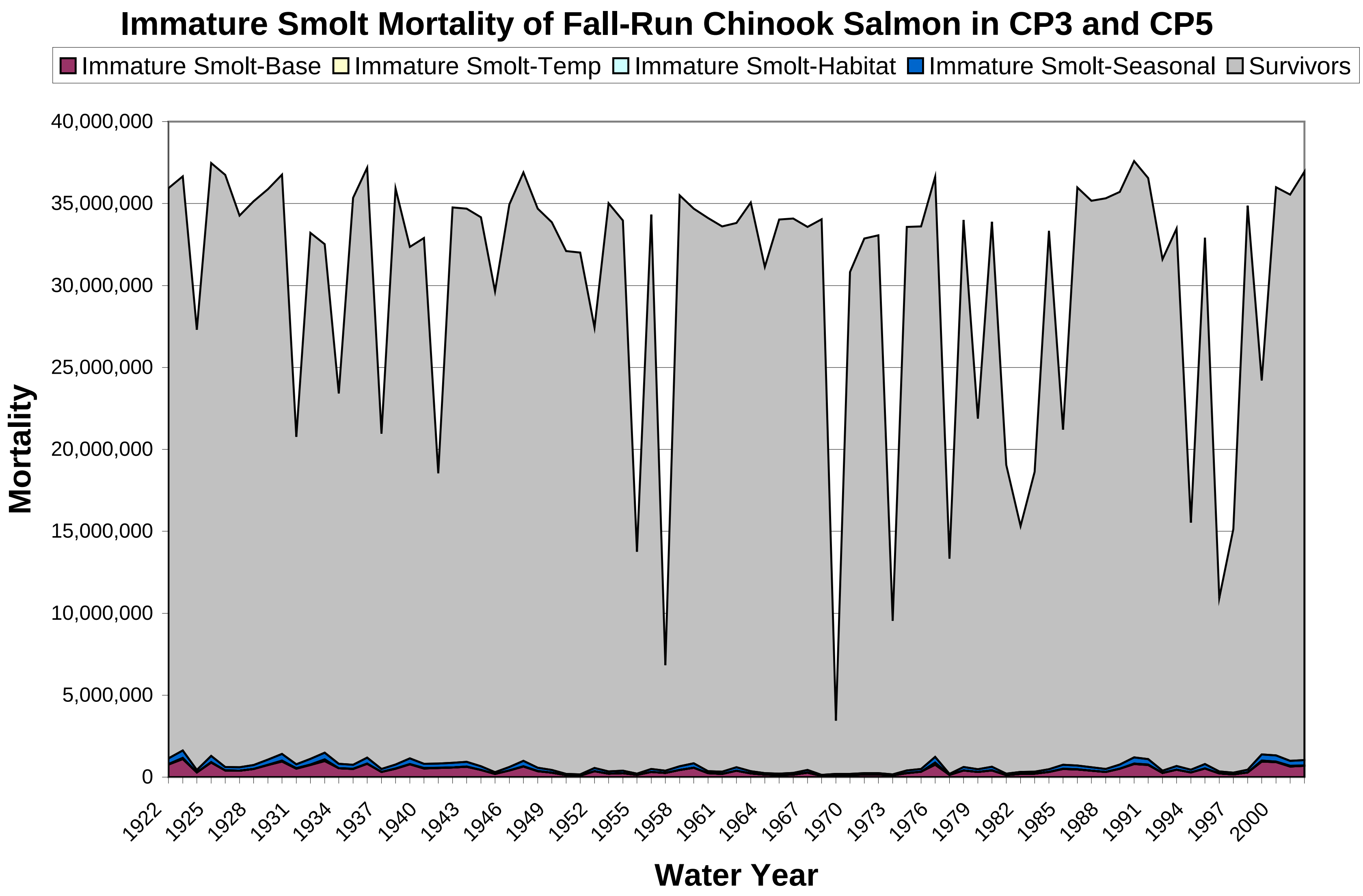

Figure B-46D. Source of mortality of fall-run Chinook salmon immature smolts in CP3 and CP5 based on the 1999-2006 population average.

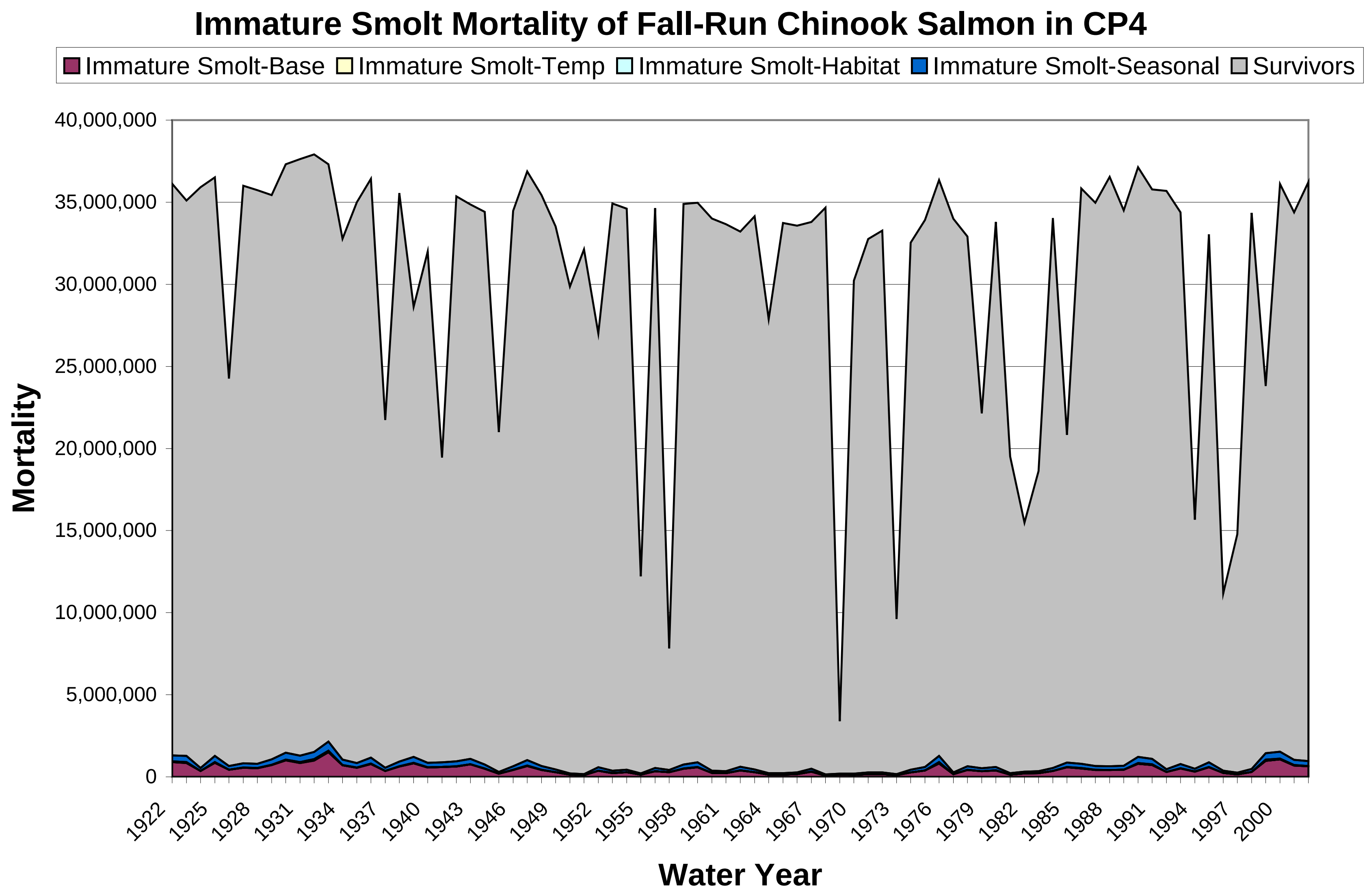

Figure B-46E. Source of mortality of fall-run Chinook salmon immature smolts in CP4 based on the 1999-2006 population average.

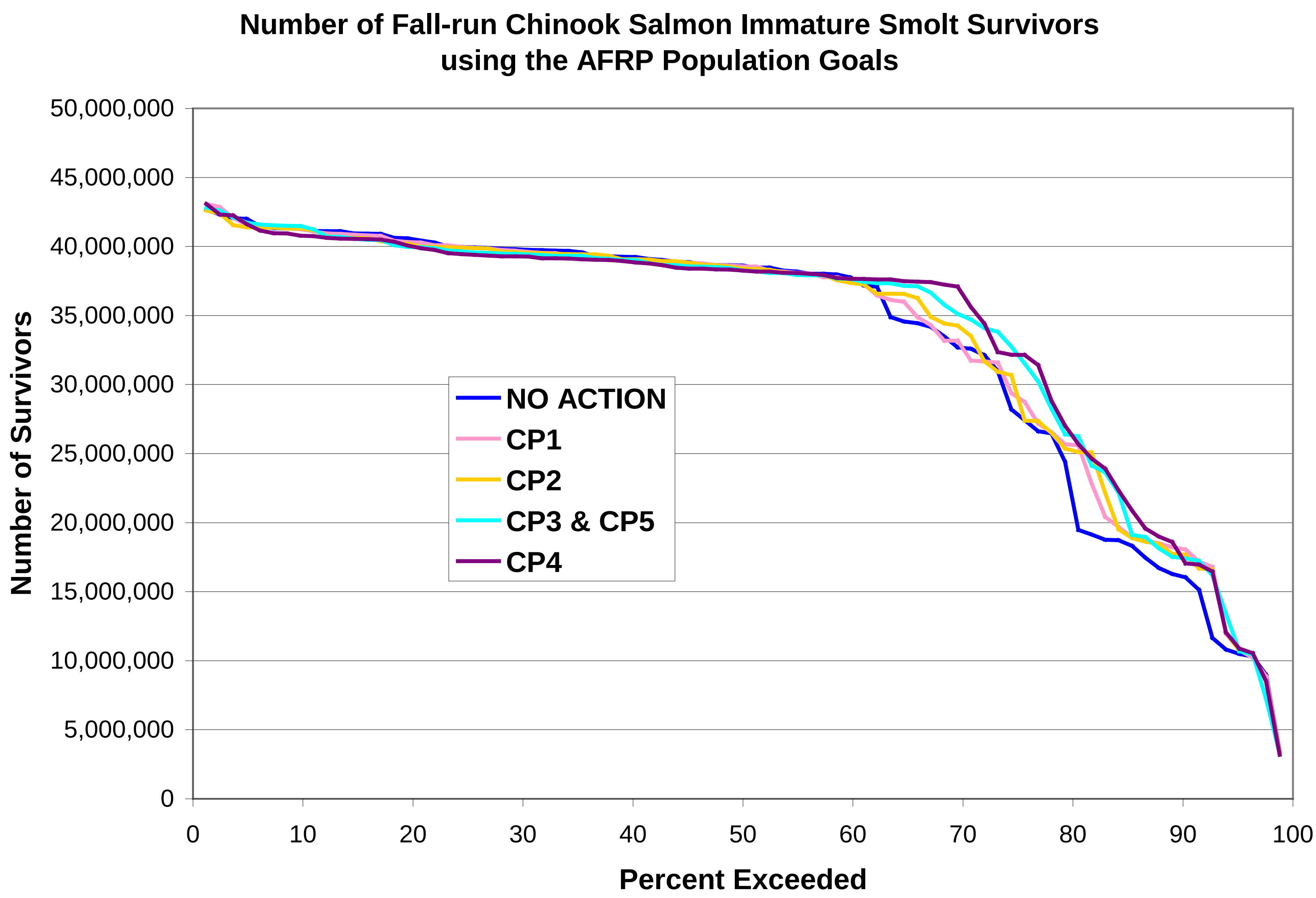

Figure B-47A. Frequency distribution of the number of fall-run Chinook salmon immature smolt survivors during the 1921-2003 simulation period based on the AFRP population goals.

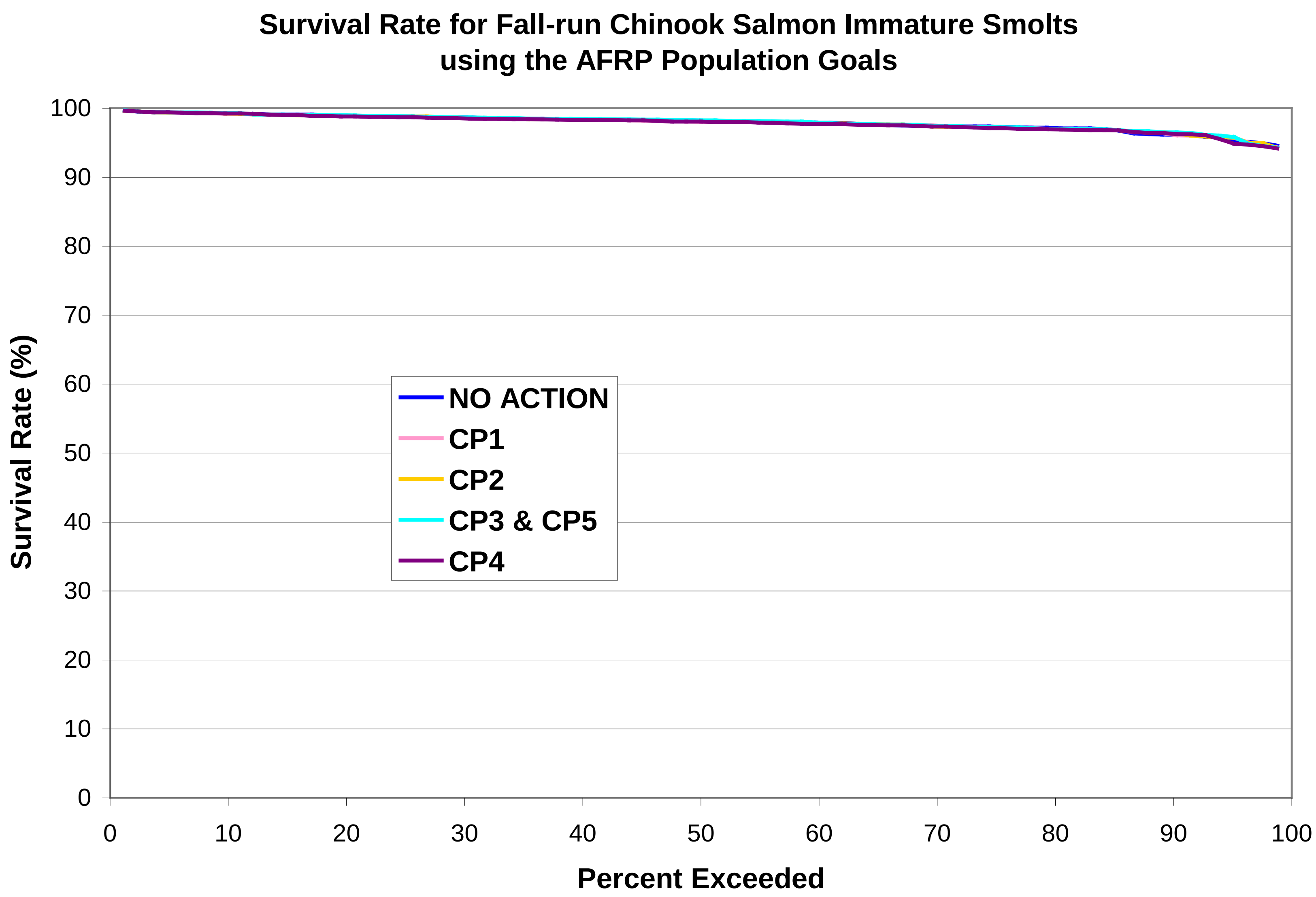

Figure B-47B. Frequency distribution of the survival rate of fall-run Chinook salmon immature smolts during the 1921-2003 simulation period based on the AFRP population goals.

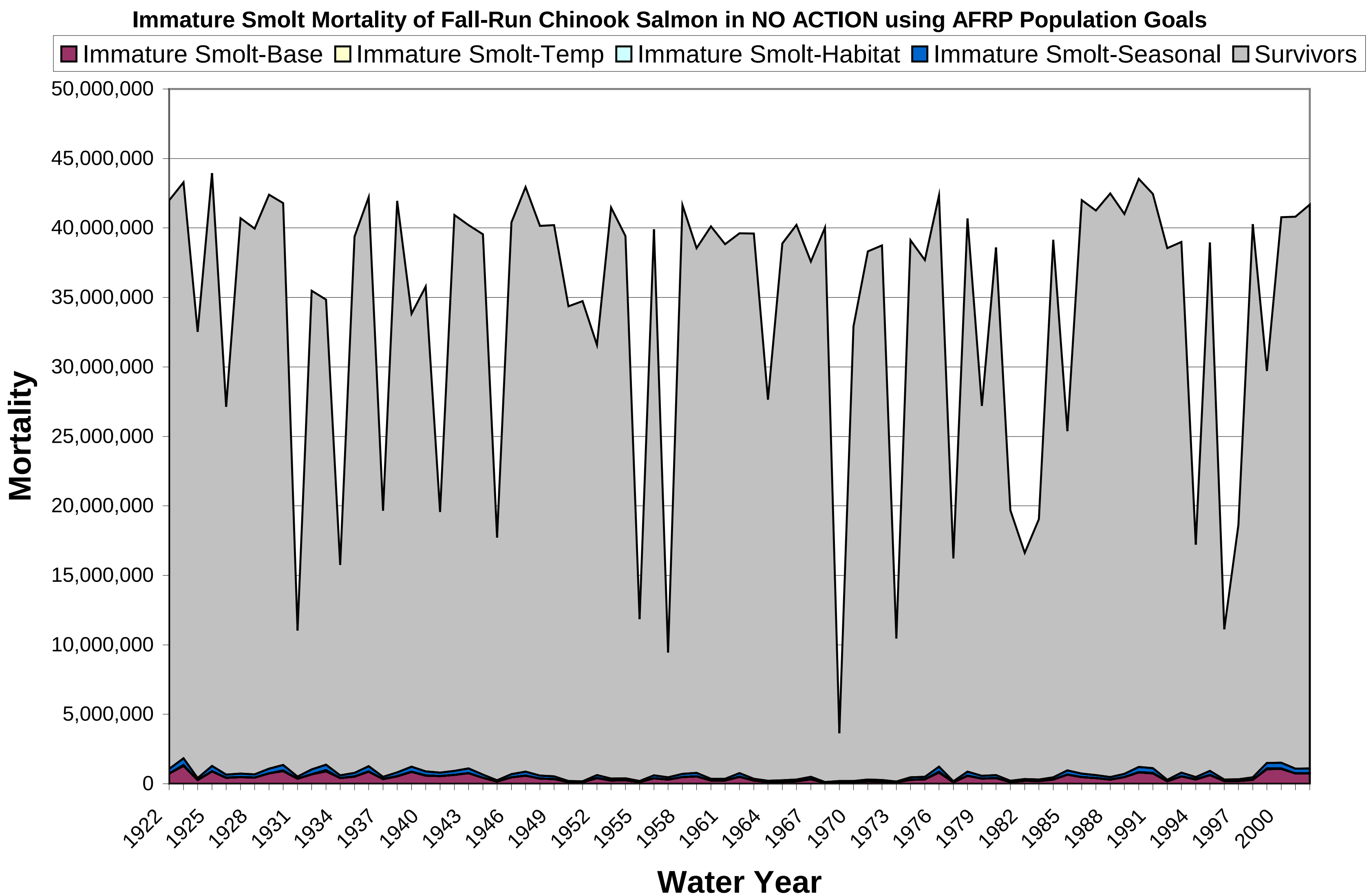

Figure B-48A. Source of mortality of fall-run Chinook salmon immature smolts in NO ACTION based on the AFRP population goals.

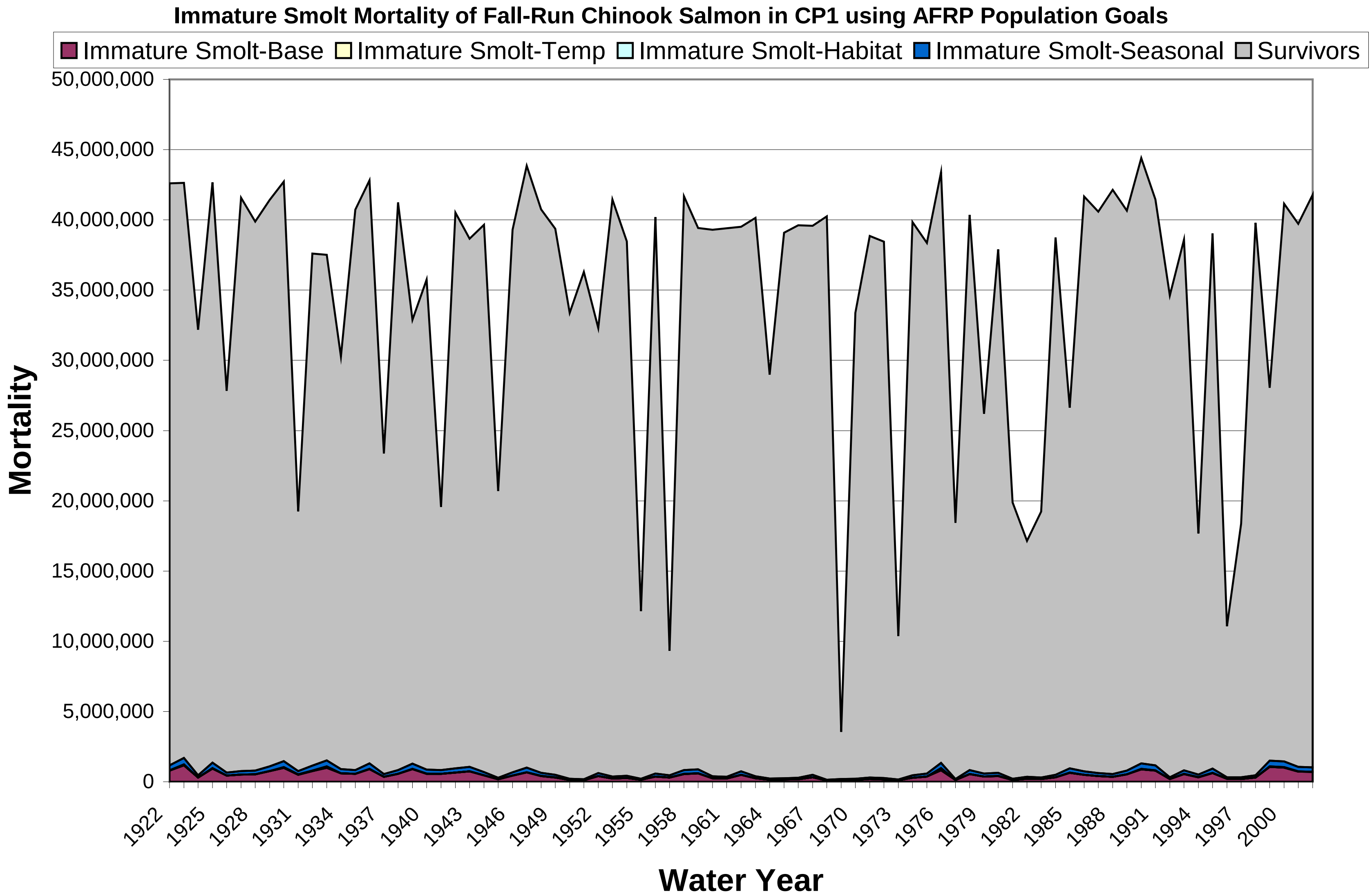

Figure B-48B. Source of mortality of fall-run Chinook salmon immature smolts in CP1 based on the AFRP population goals.

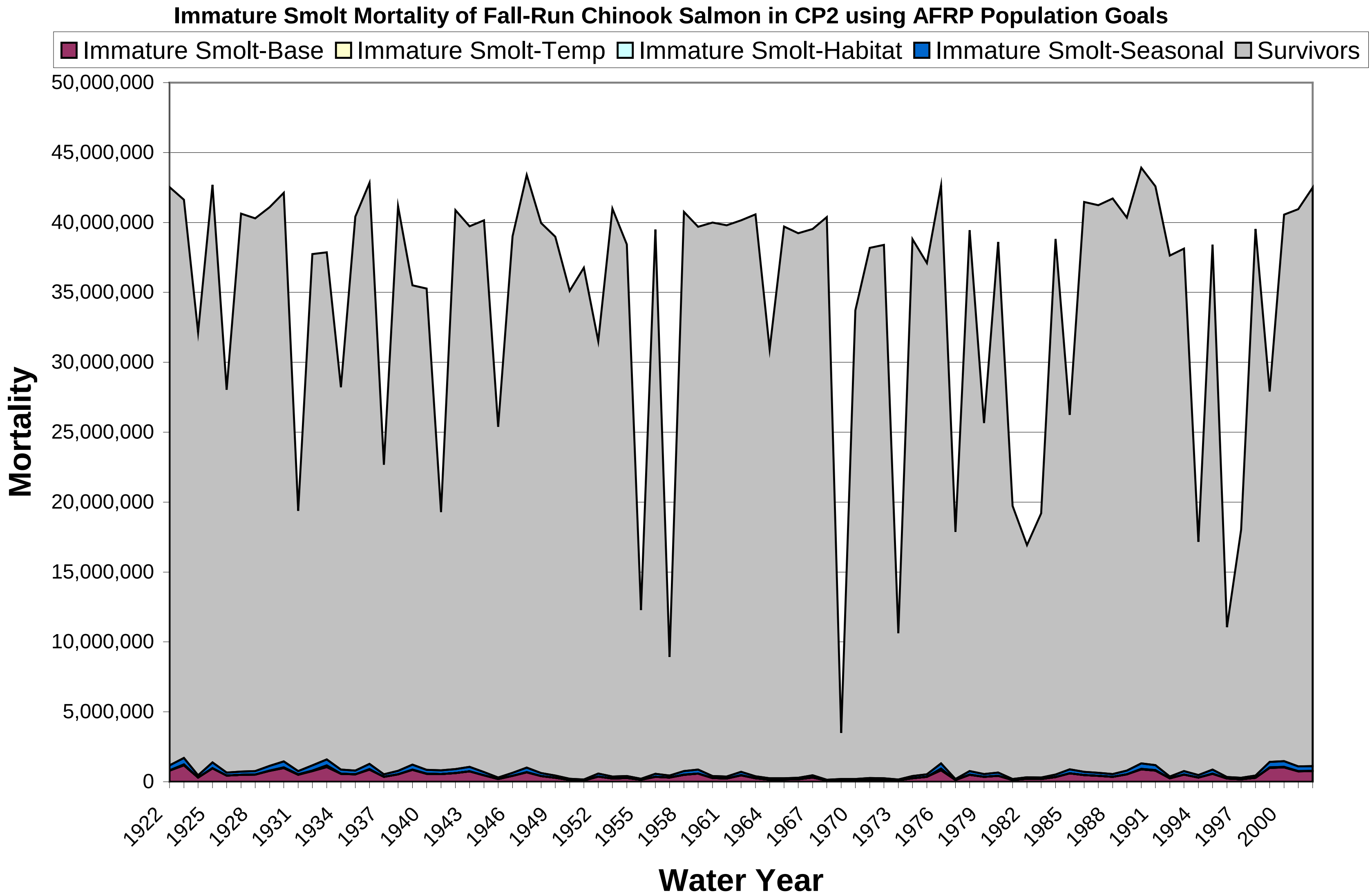

Figure B-48C. Source of mortality of fall-run Chinook salmon immature smolts in CP2 based on the AFRP population goals.

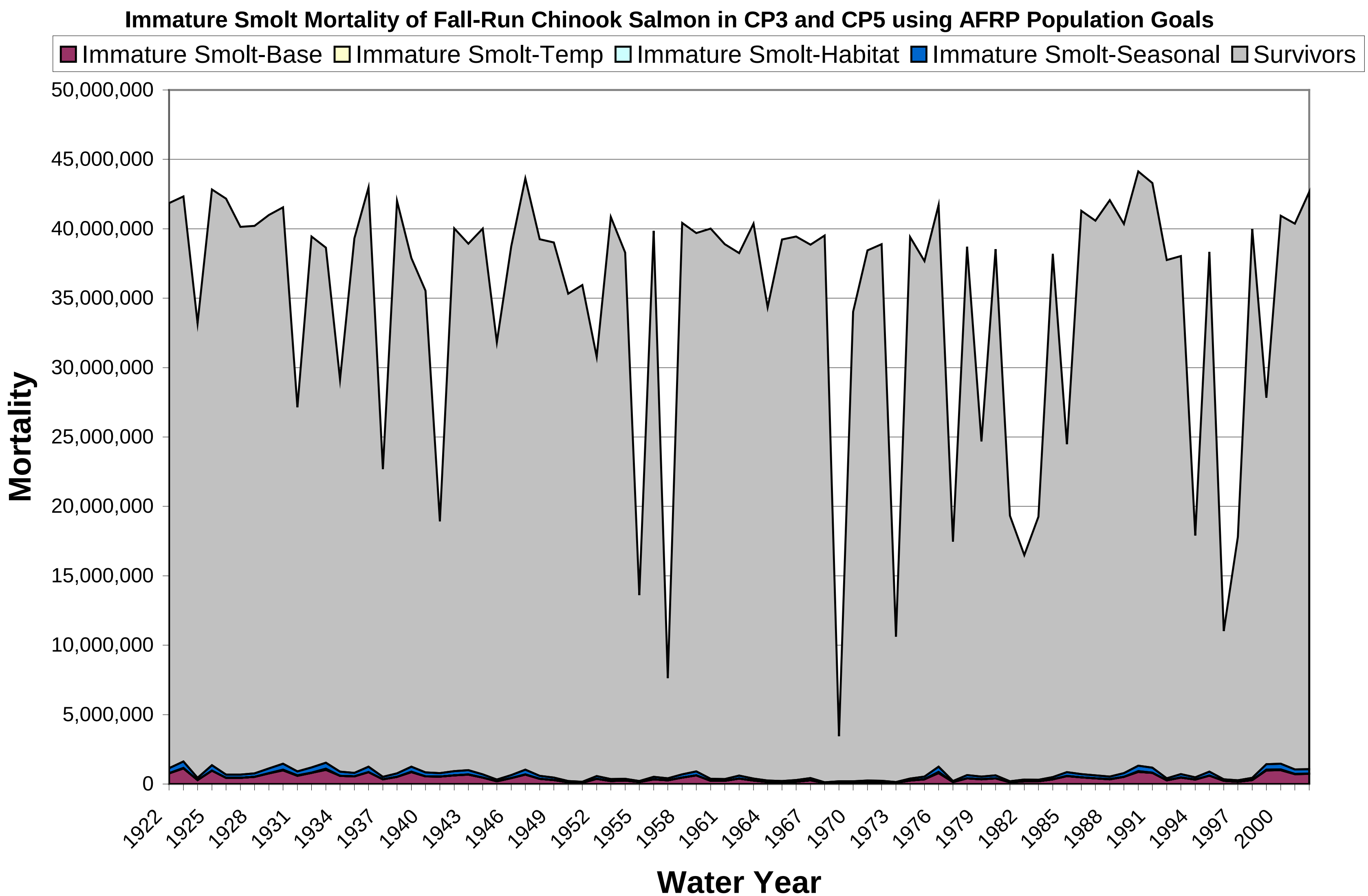

Figure B-48D. Source of mortality of fall-run Chinook salmon immature smolts in CP3 and CP5 based on the AFRP population goals.

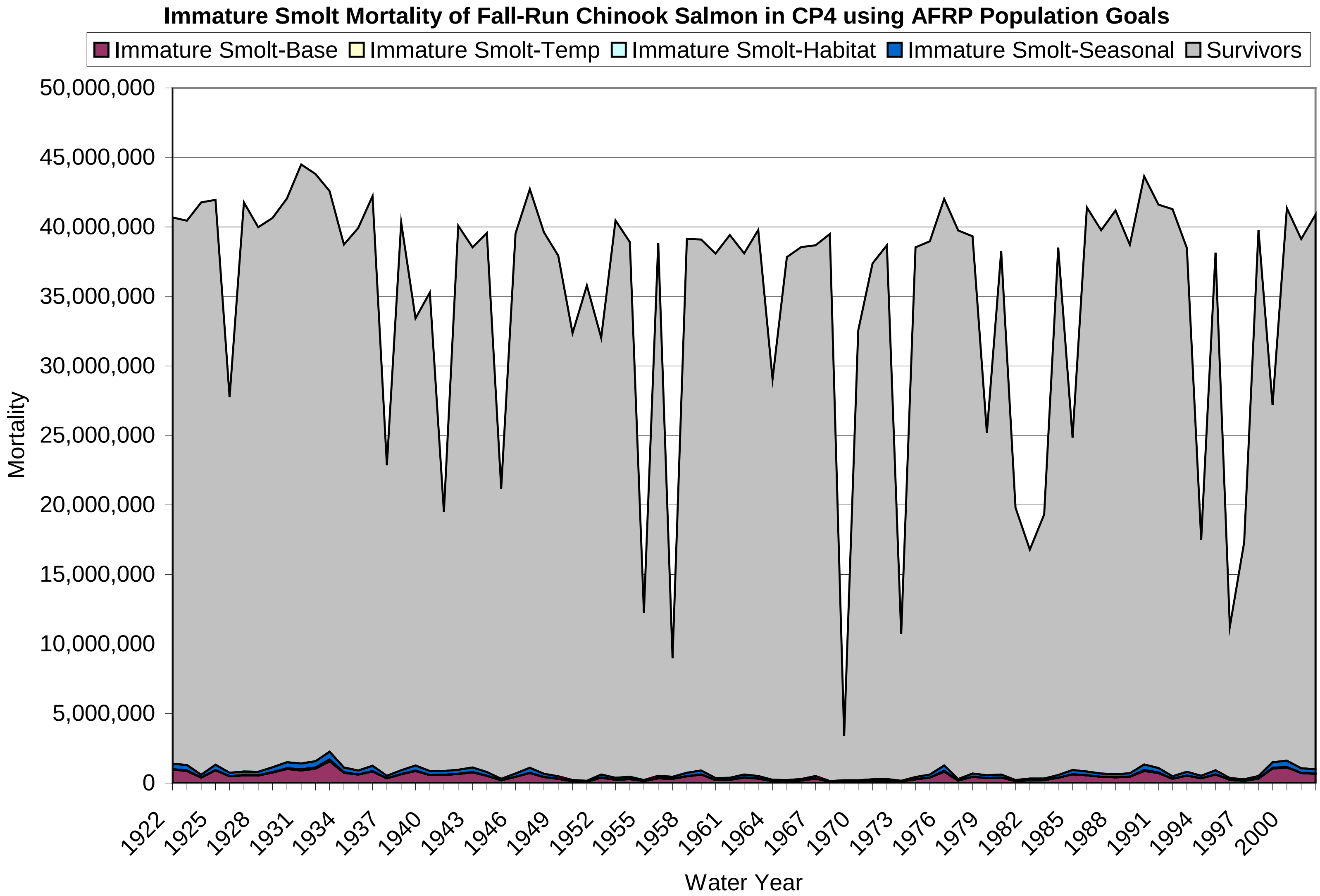

Figure B-48E. Source of mortality of fall-run Chinook salmon immature smolts in CP4 based on the AFRP population goals.

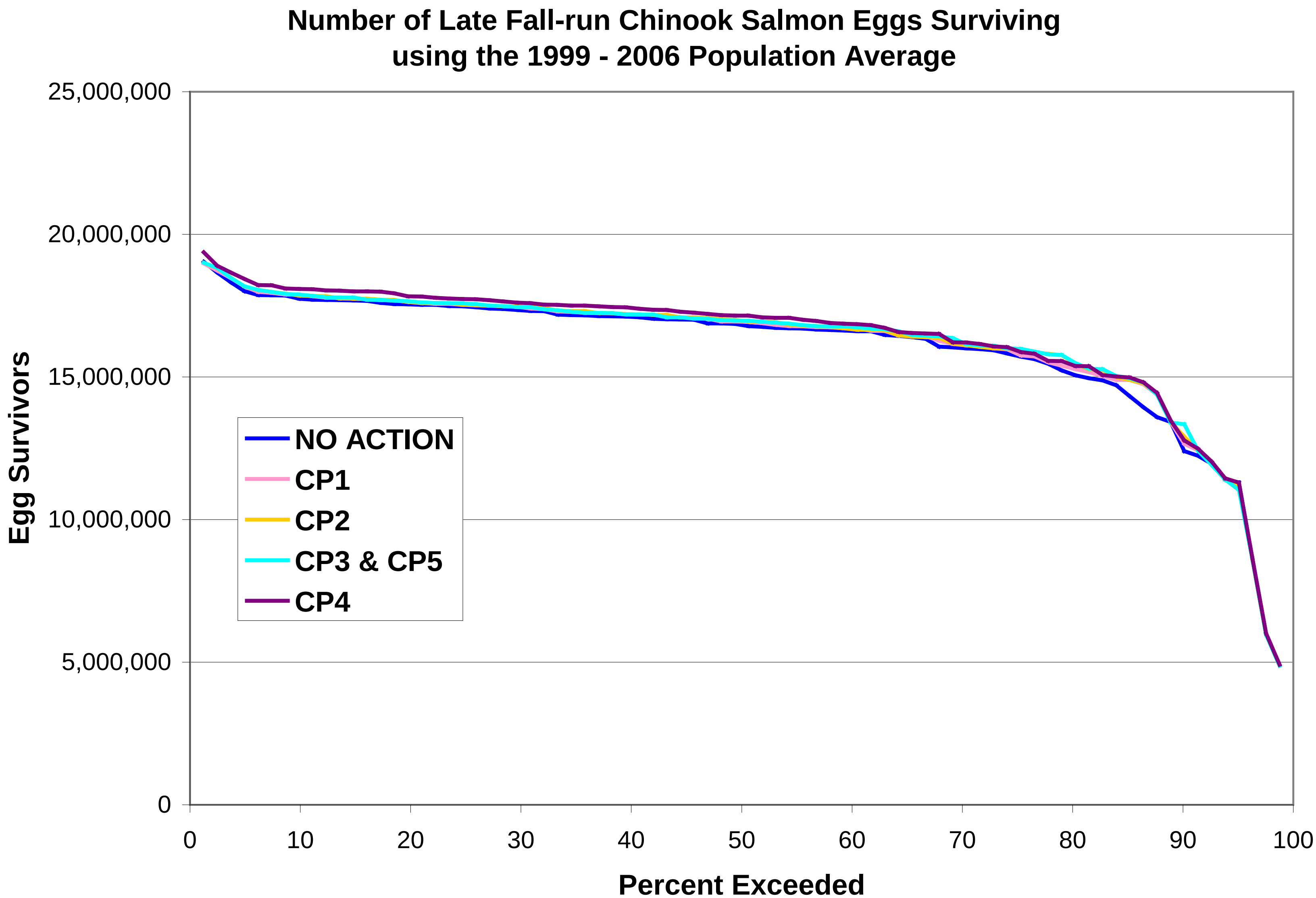

Figure B-49A. Frequency distribution of the number of late fall-run Chinook salmon egg survivors during the 1921-2003 simulation period based on the 1999 -2006 population average.

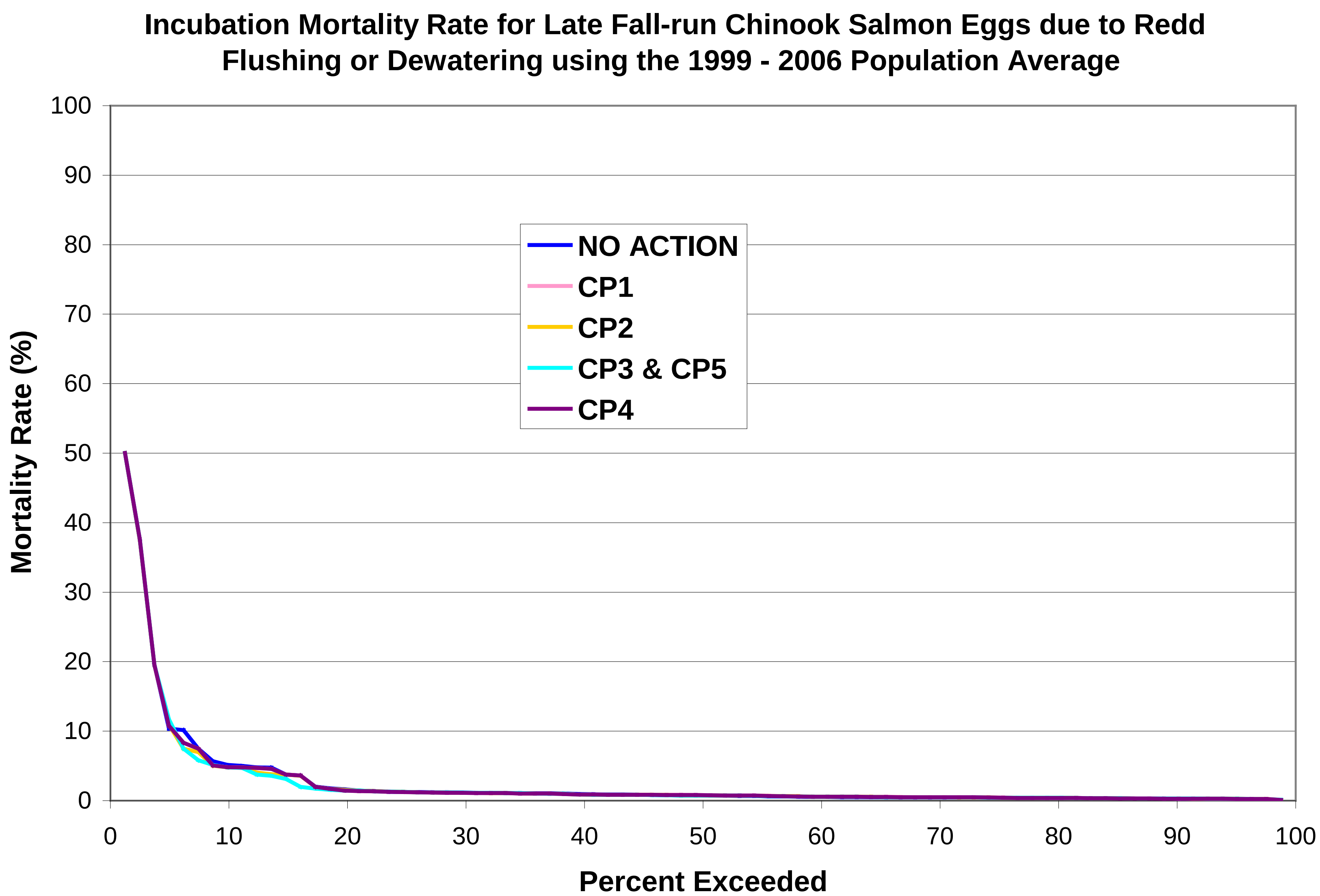

Figure B-49B. Frequency distribution of the incubation mortality rate of late fall-run Chinook salmon eggs due to the flushing or dewatering of redds during the 1921-2003 simulation period based on the 1999-2006 population average.

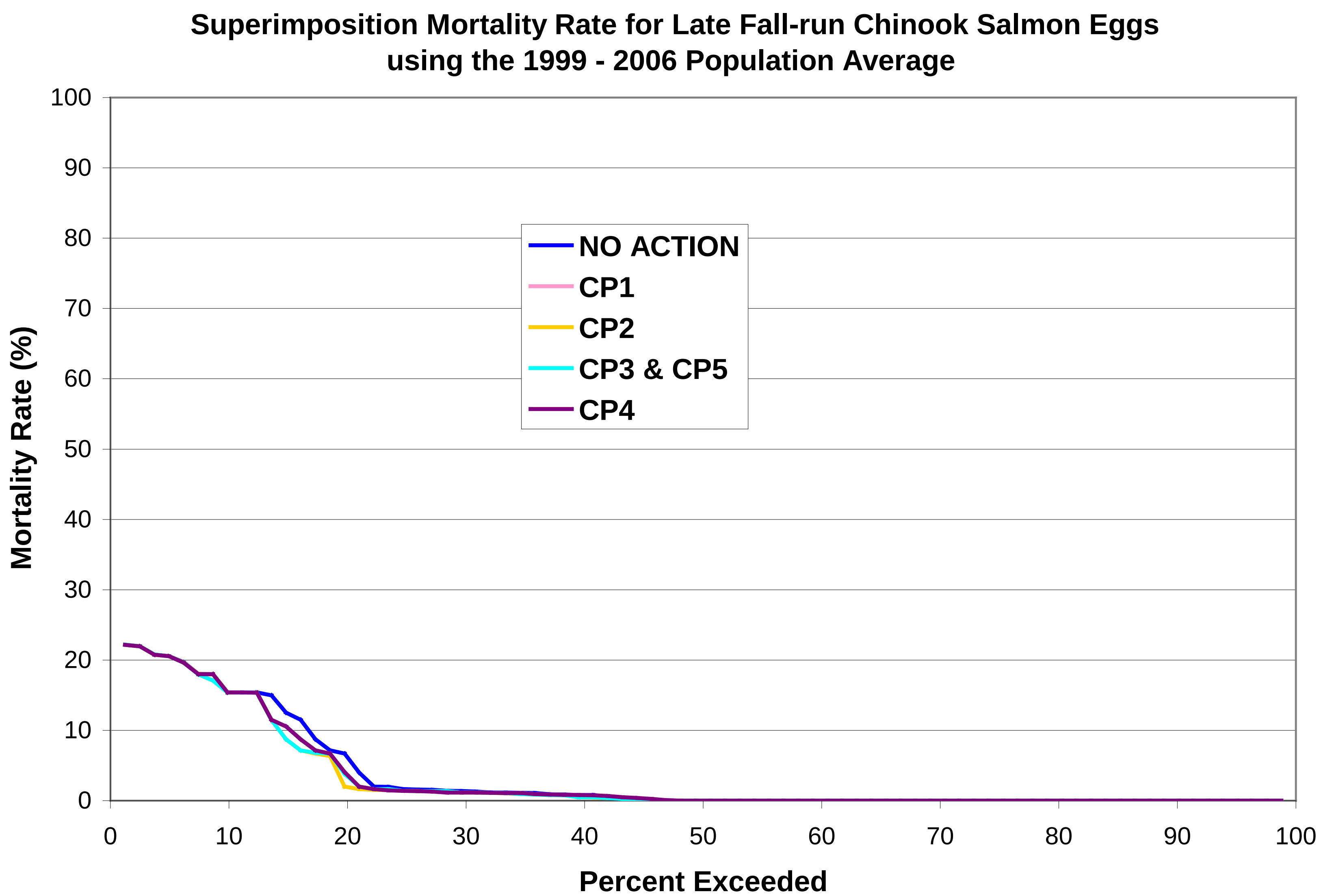

Figure B-49C. Frequency distribution of the superimposition mortality rate of late fall-run Chinook salmon eggs during the 1921-2003 simulation period based on the 1999-2006 population average.

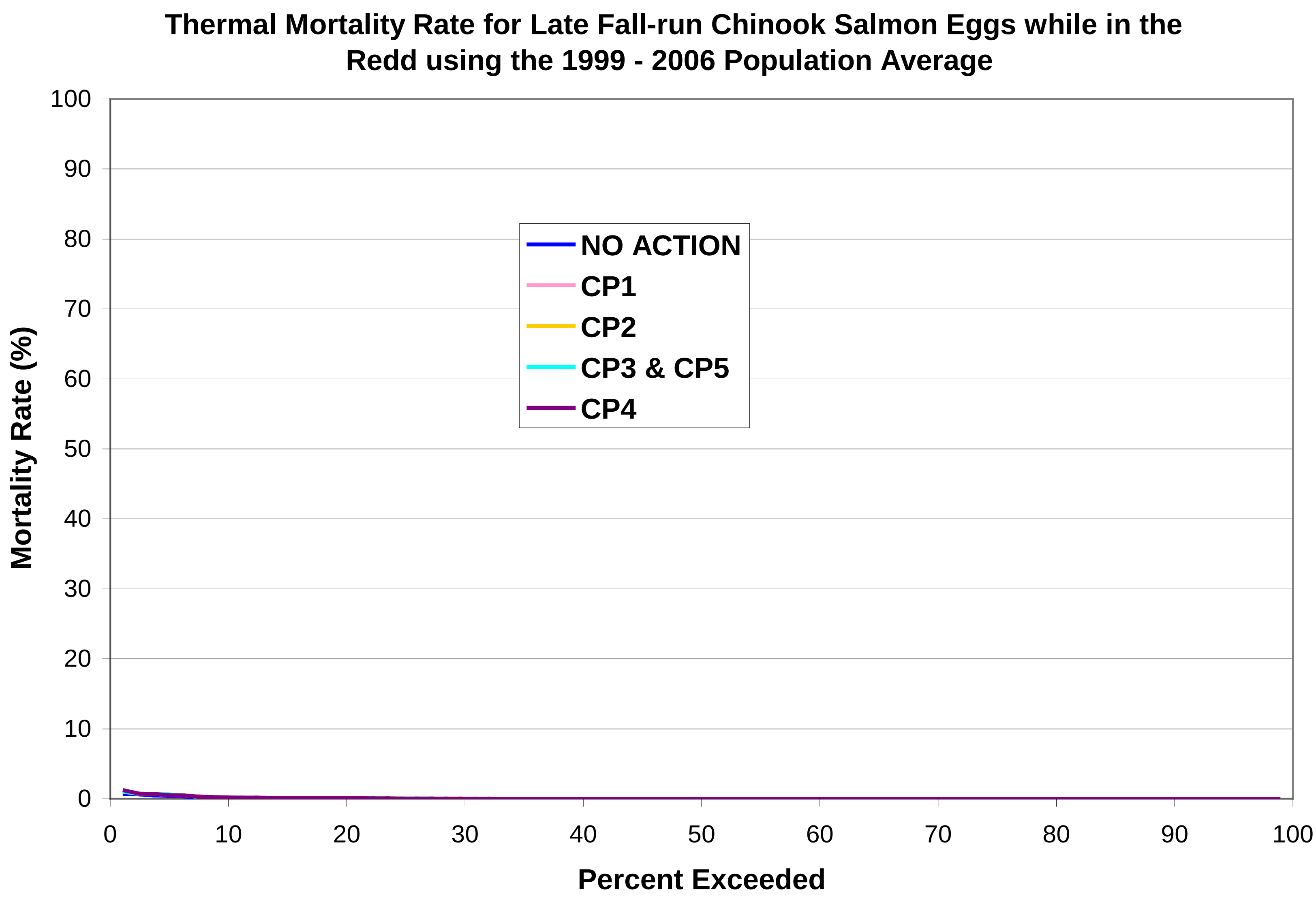

Figure B-49D. Frequency distribution of the thermal mortality rate of late fall-run Chinook salmon eggs while in the redd during the 1921-2003 simulation period based on the 1999-2006 population average.

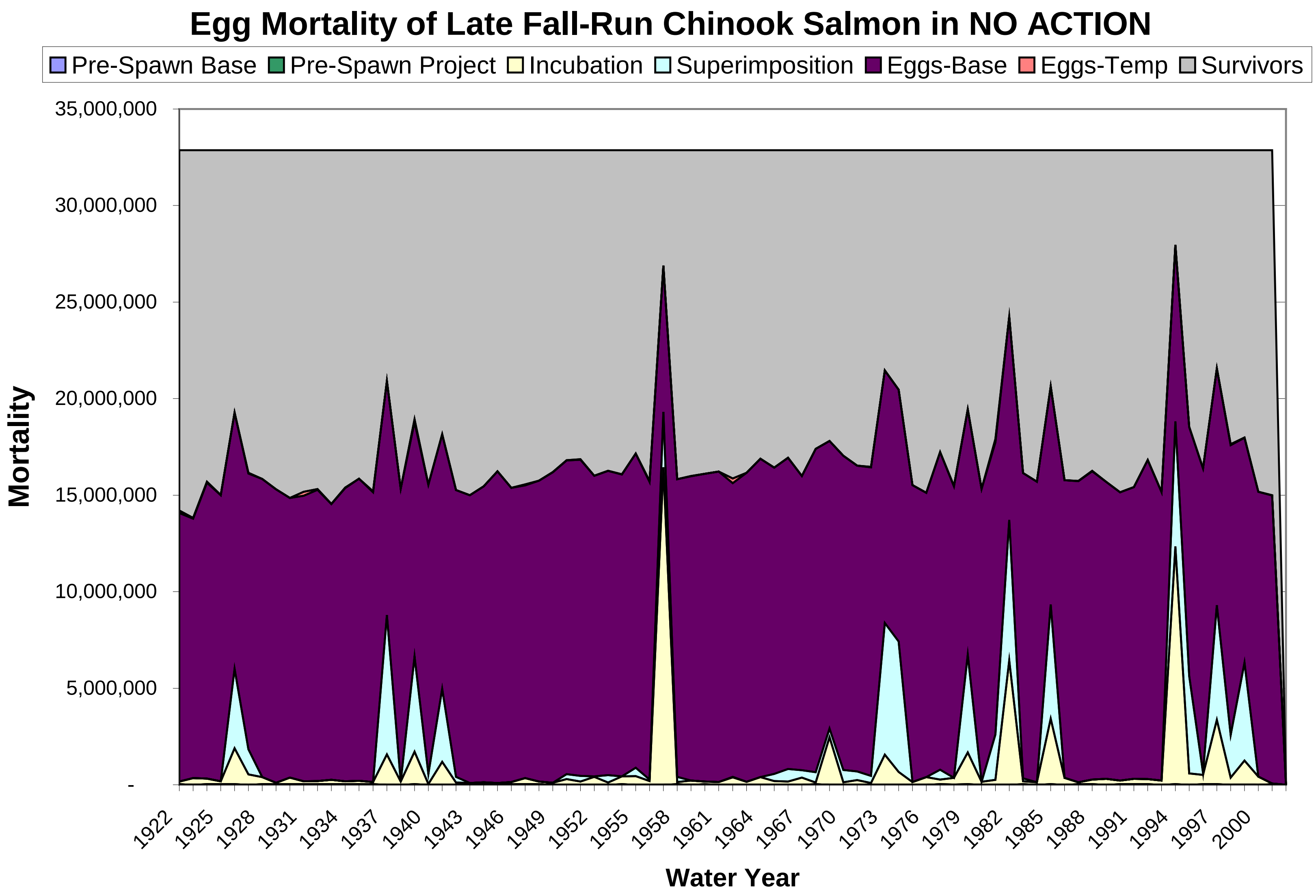

Figure B-50A. Source of mortality of late fall-run Chinook salmon eggs in NO ACTION based on the 1999-2006 population average.

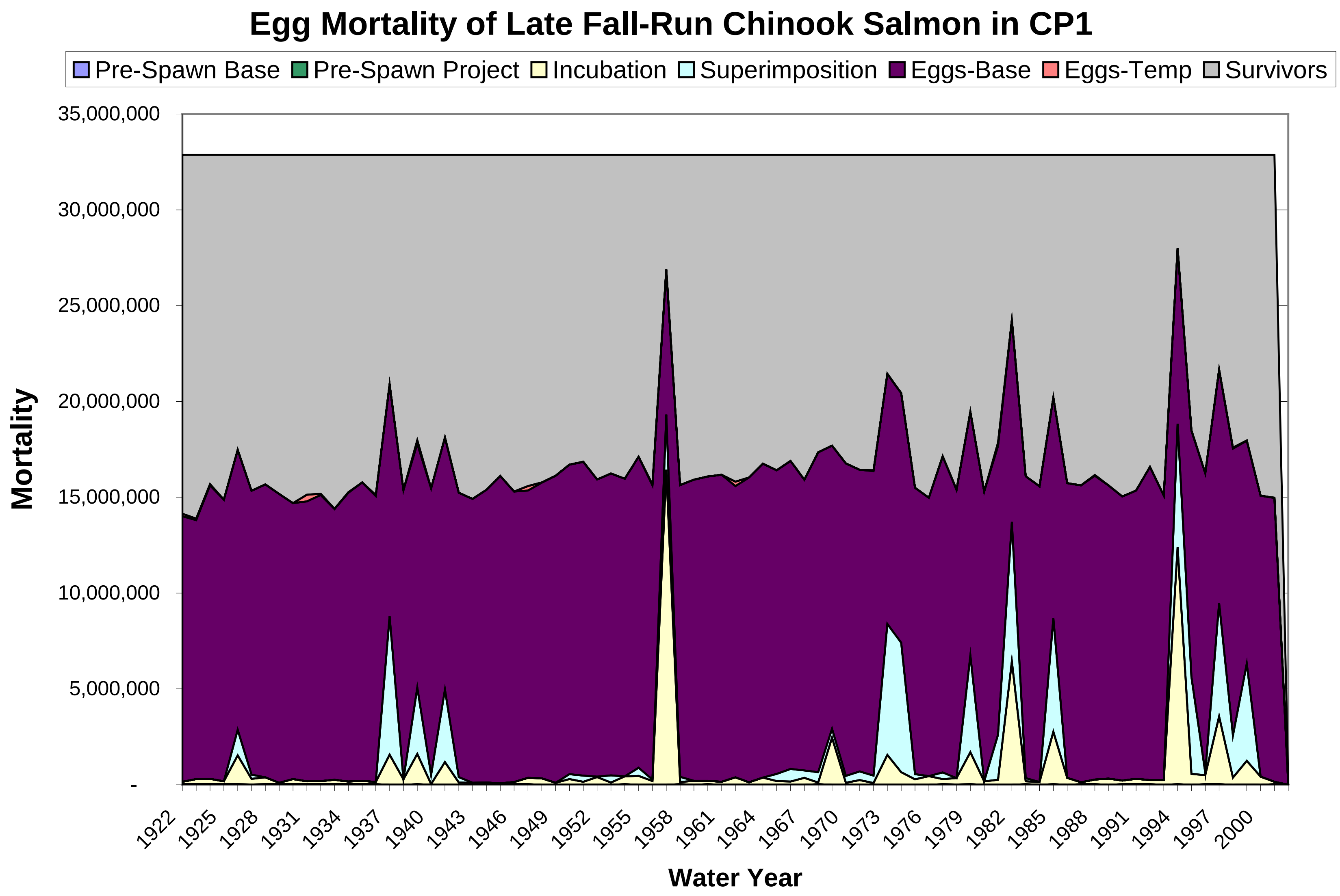

Figure B-50B. Source of mortality of late fall-run Chinook salmon eggs in CP1 based on the 1999-2006 population average.

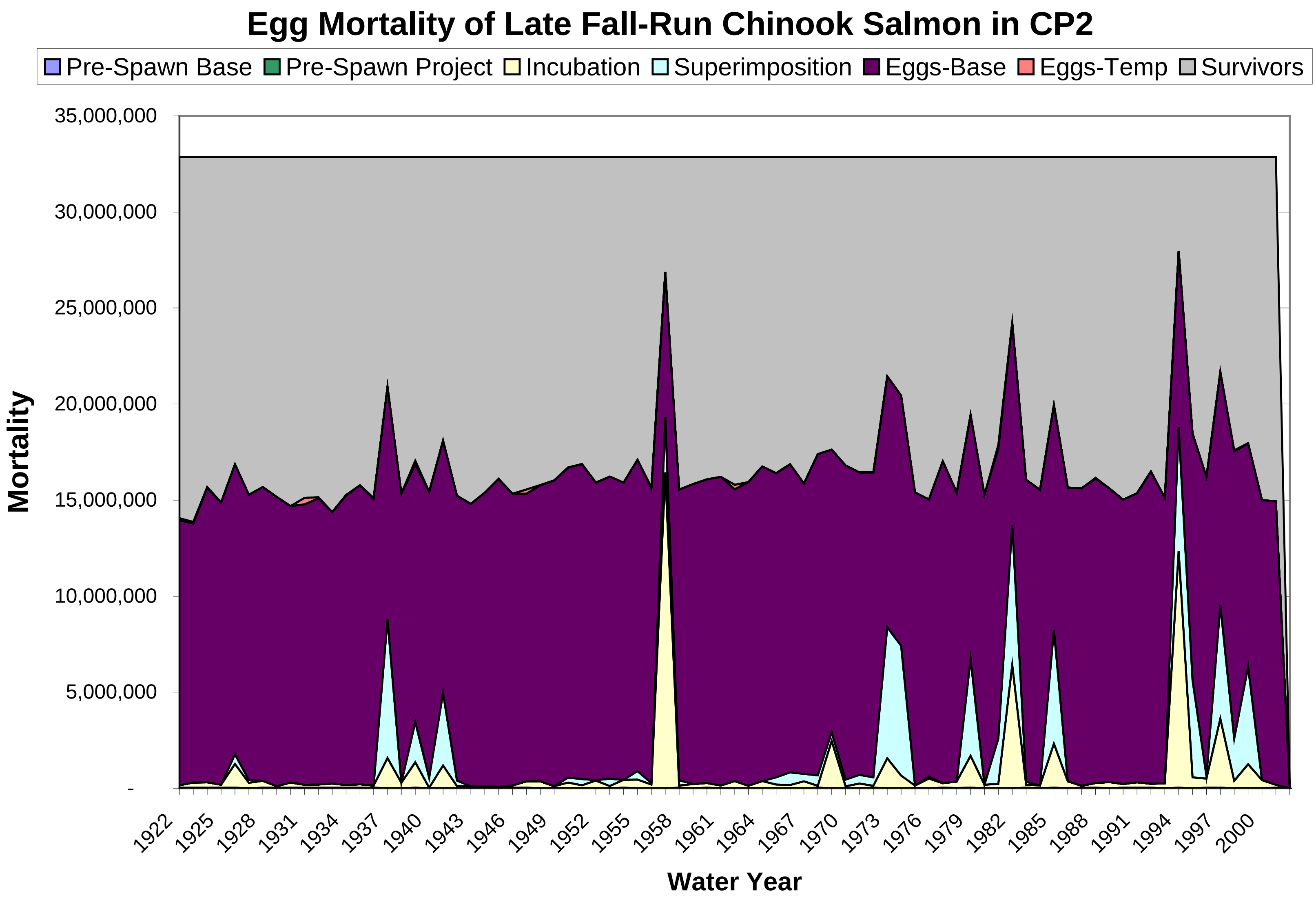

Figure B-50C. Source of mortality of late fall-run Chinook salmon eggs in CP2 based on the 1999-2006 population average.

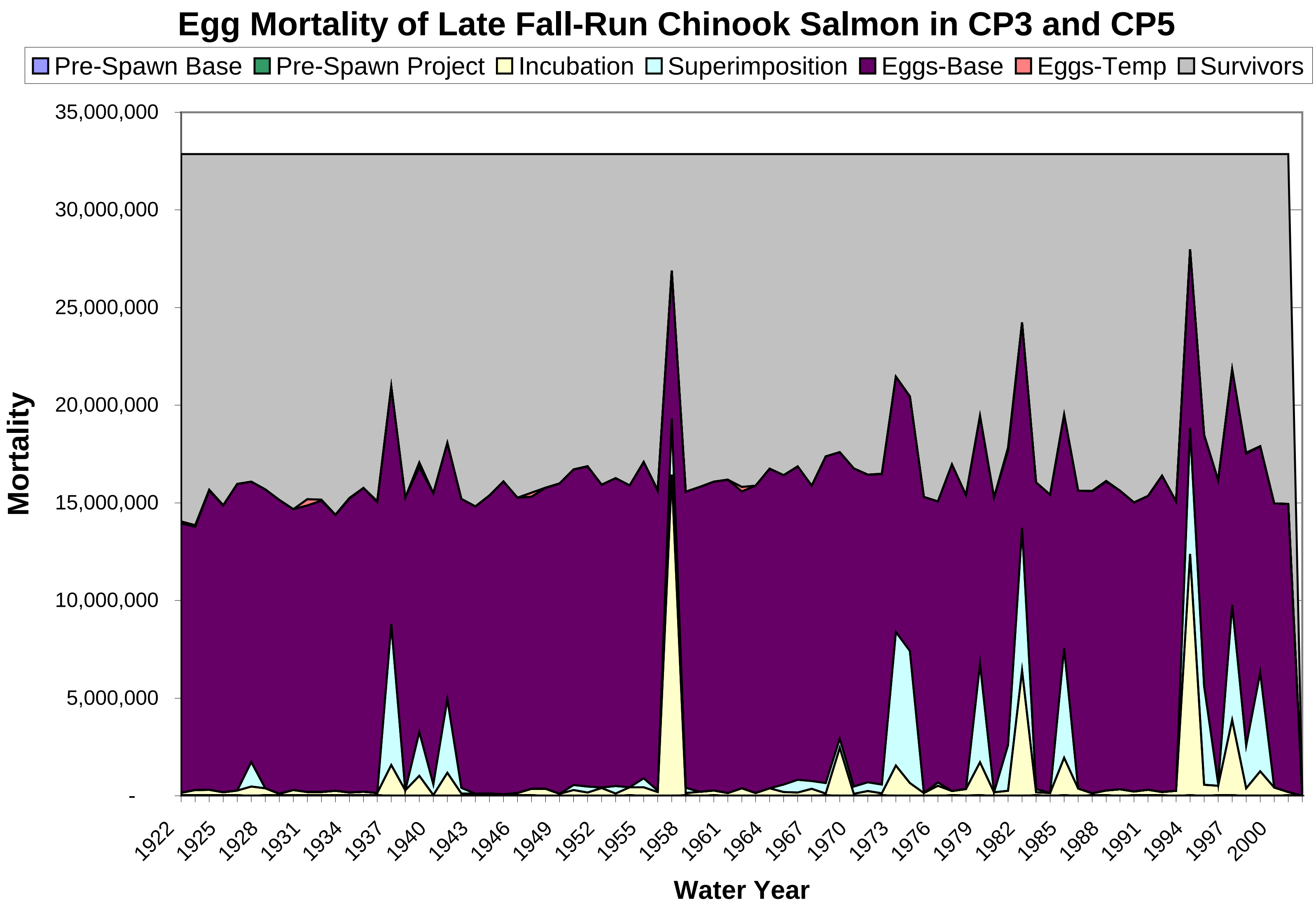

Figure B-50D. Source of mortality of late fall-run Chinook salmon eggs in CP3 and CP5 based on the 1999-2006 population average.

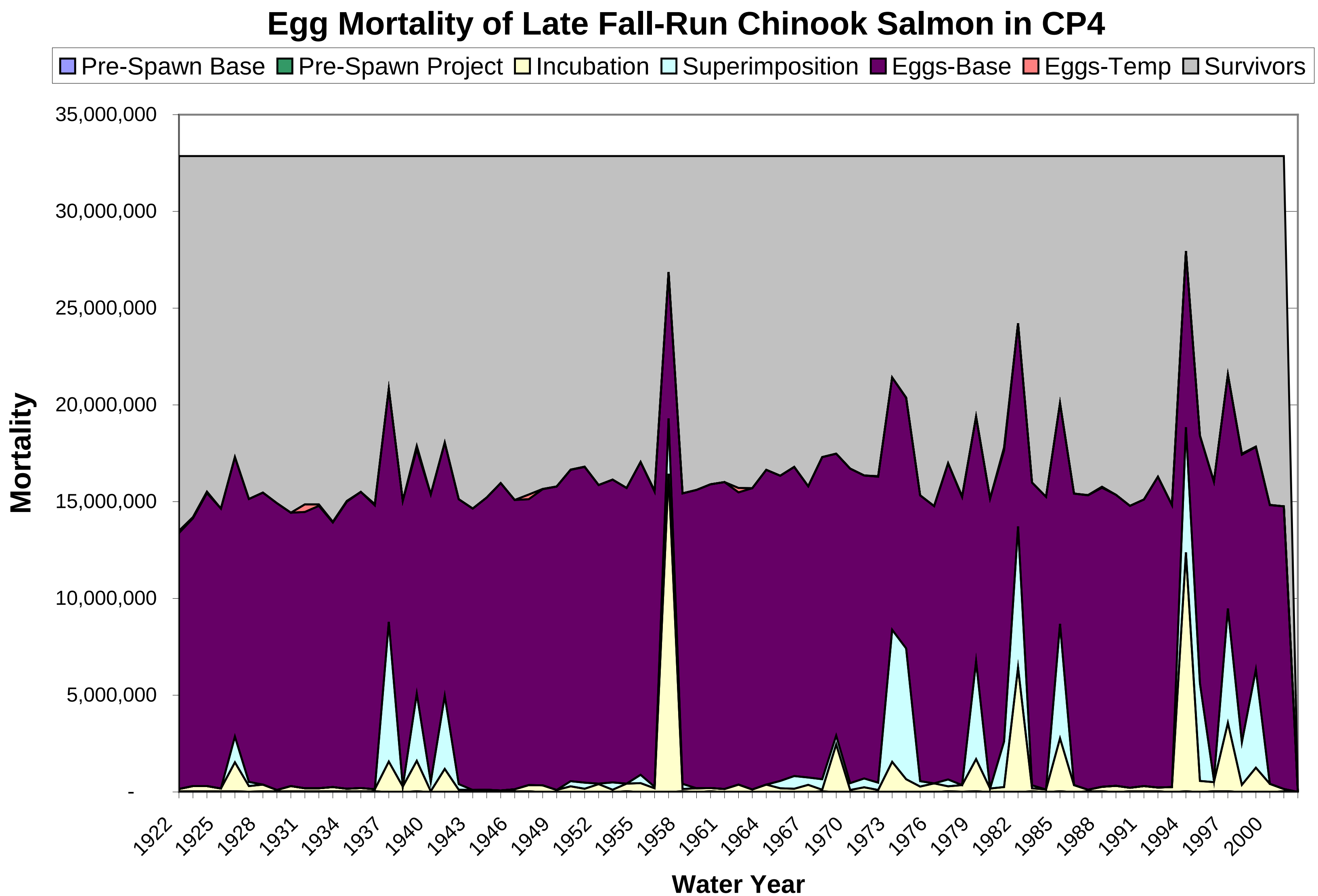

Figure B-50E. Source of mortality of late fall-run Chinook salmon eggs in CP4 based on the 1999-2006 population average.

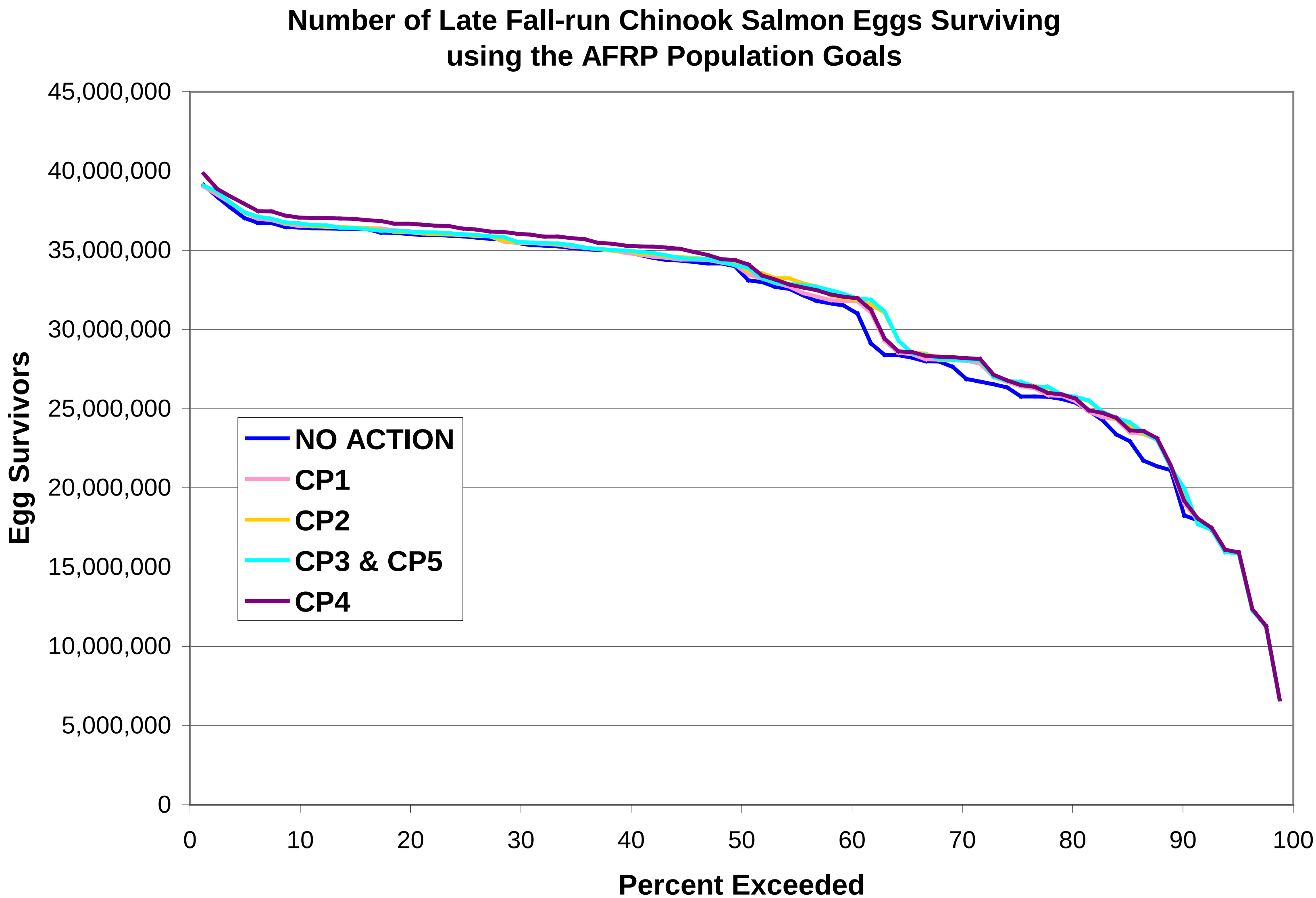

Figure B-51A. Frequency distribution of the number of late fall-run Chinook salmon egg survivors during the 1921-2003 simulation period based on the AFRP population goals.

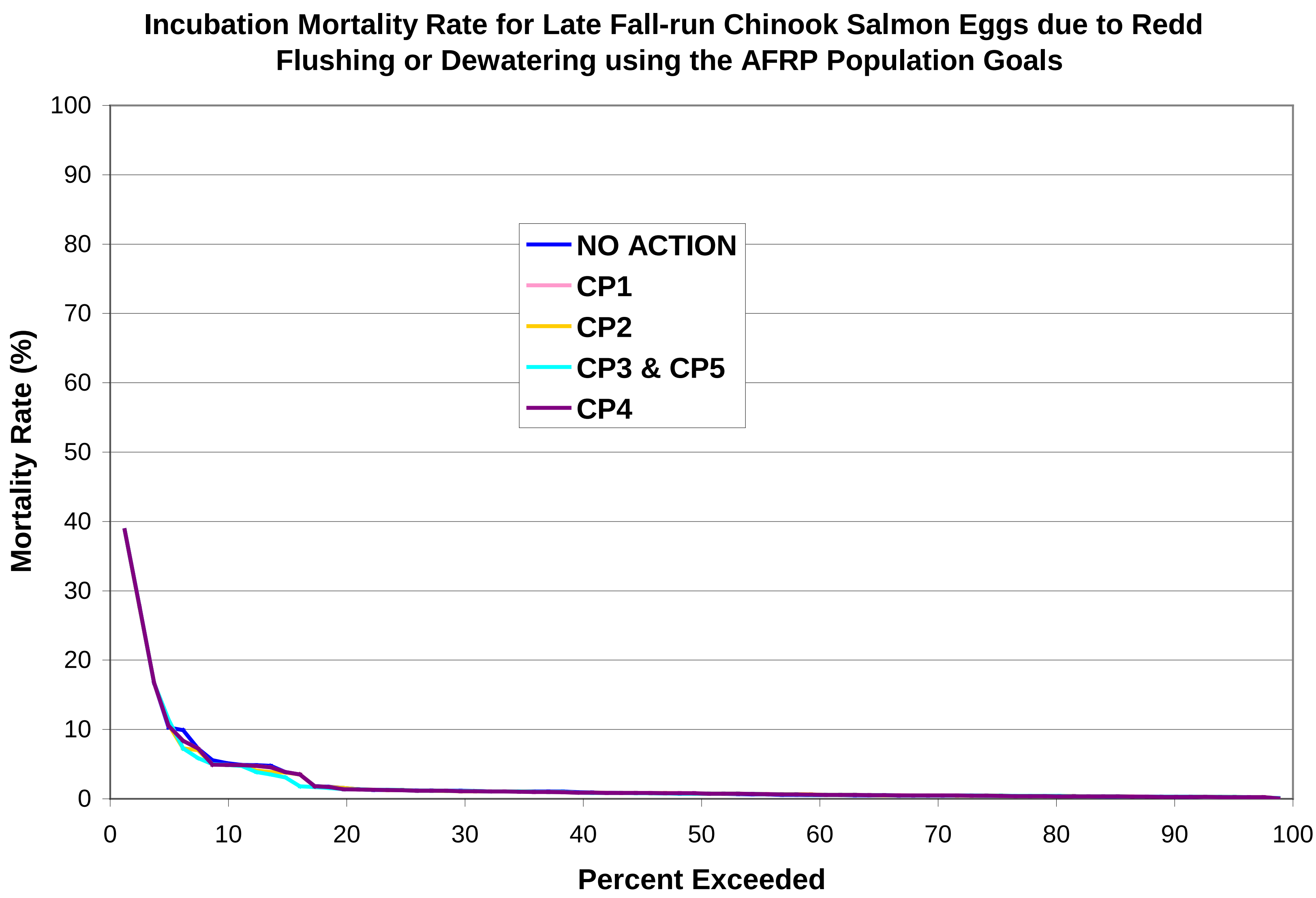

Figure B-51B. Frequency distribution of the incubation mortality rate of late fall-run Chinook salmon eggs due to the flushing or dewatering of redds during the 1921-2003 simulation period based on the AFRP population goals.

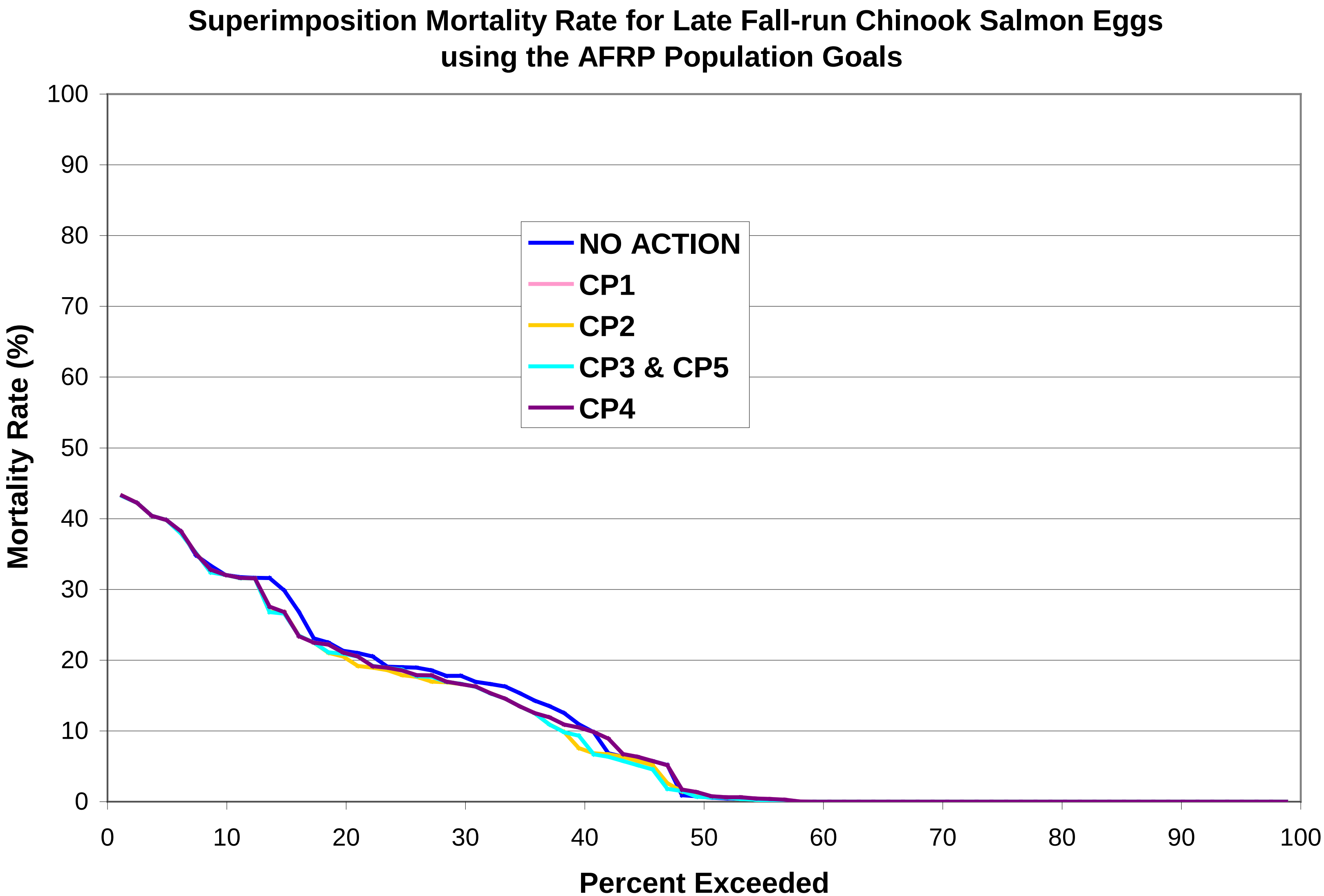

Figure B-51C. Frequency distribution of the superimposition mortality rate of late fall-run Chinook salmon eggs during the 1921-2003 simulation period based on the AFRP population goals.

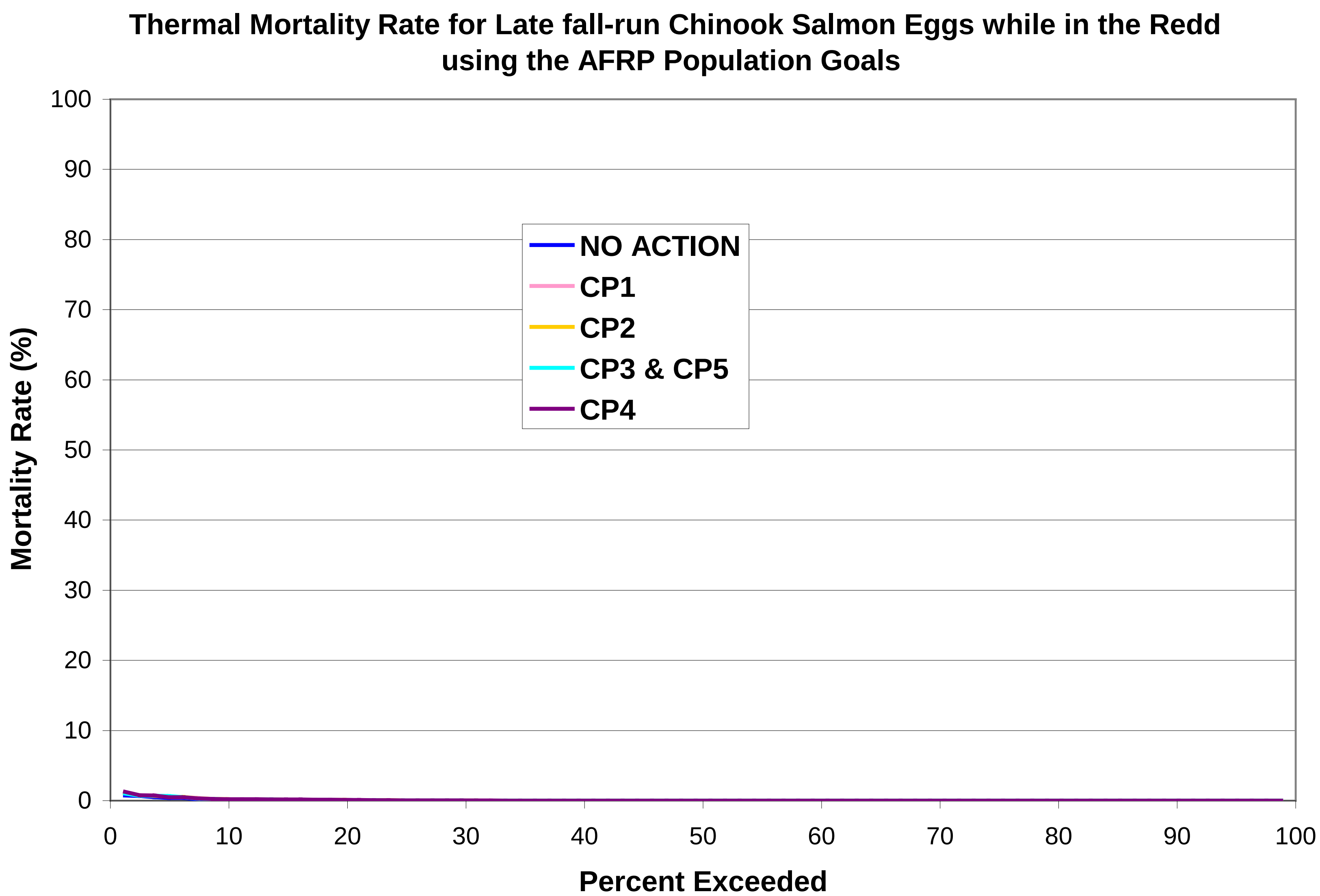

Figure B-51D. Frequency distribution of the thermal mortality rate of late fall-run Chinook salmon eggs while in the redd during the 1921-2003 simulation period based on the AFRP population goals.

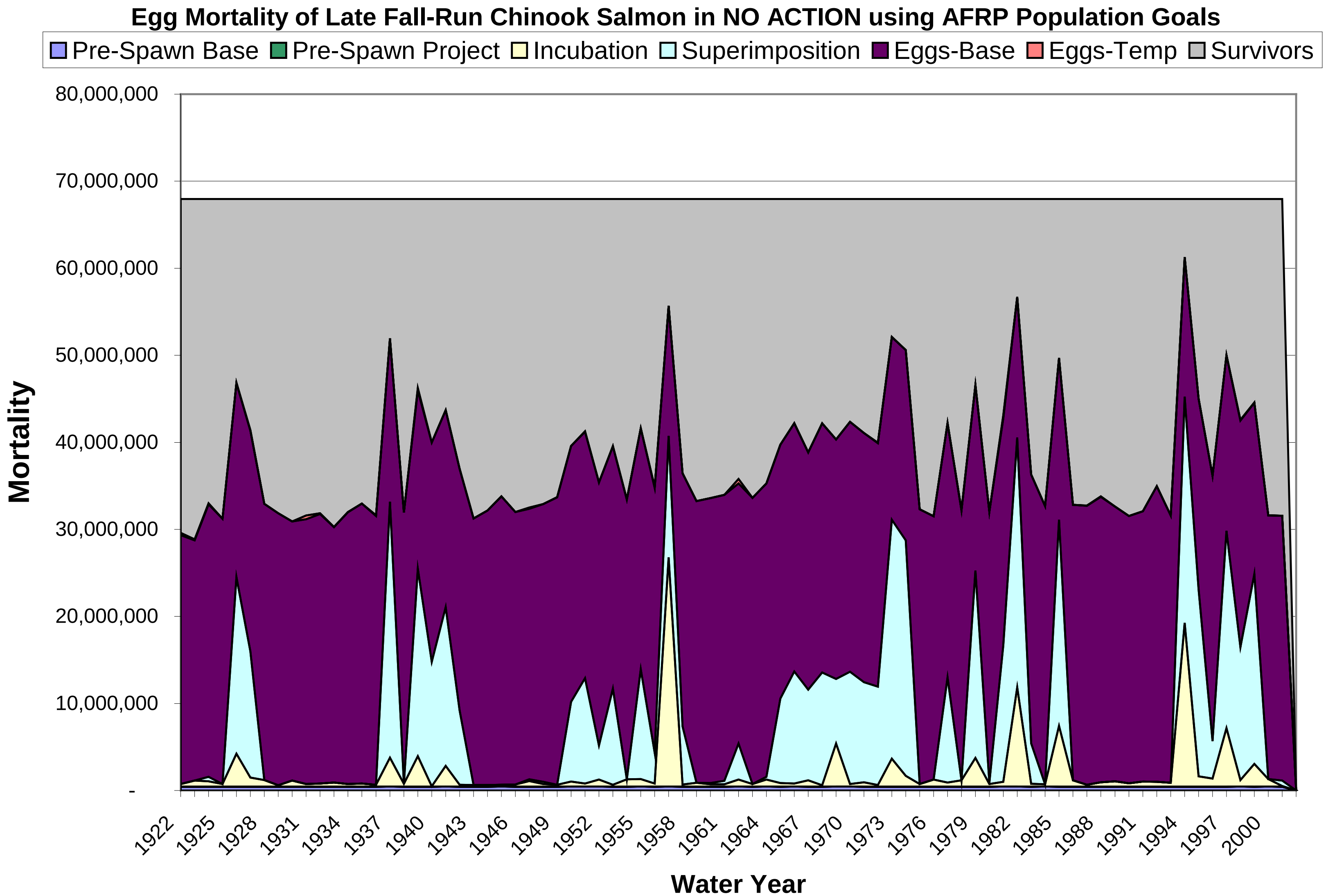

Figure B-52A. Source of mortality of late fall-run Chinook salmon eggs in NO ACTION based on the AFRP population goals.

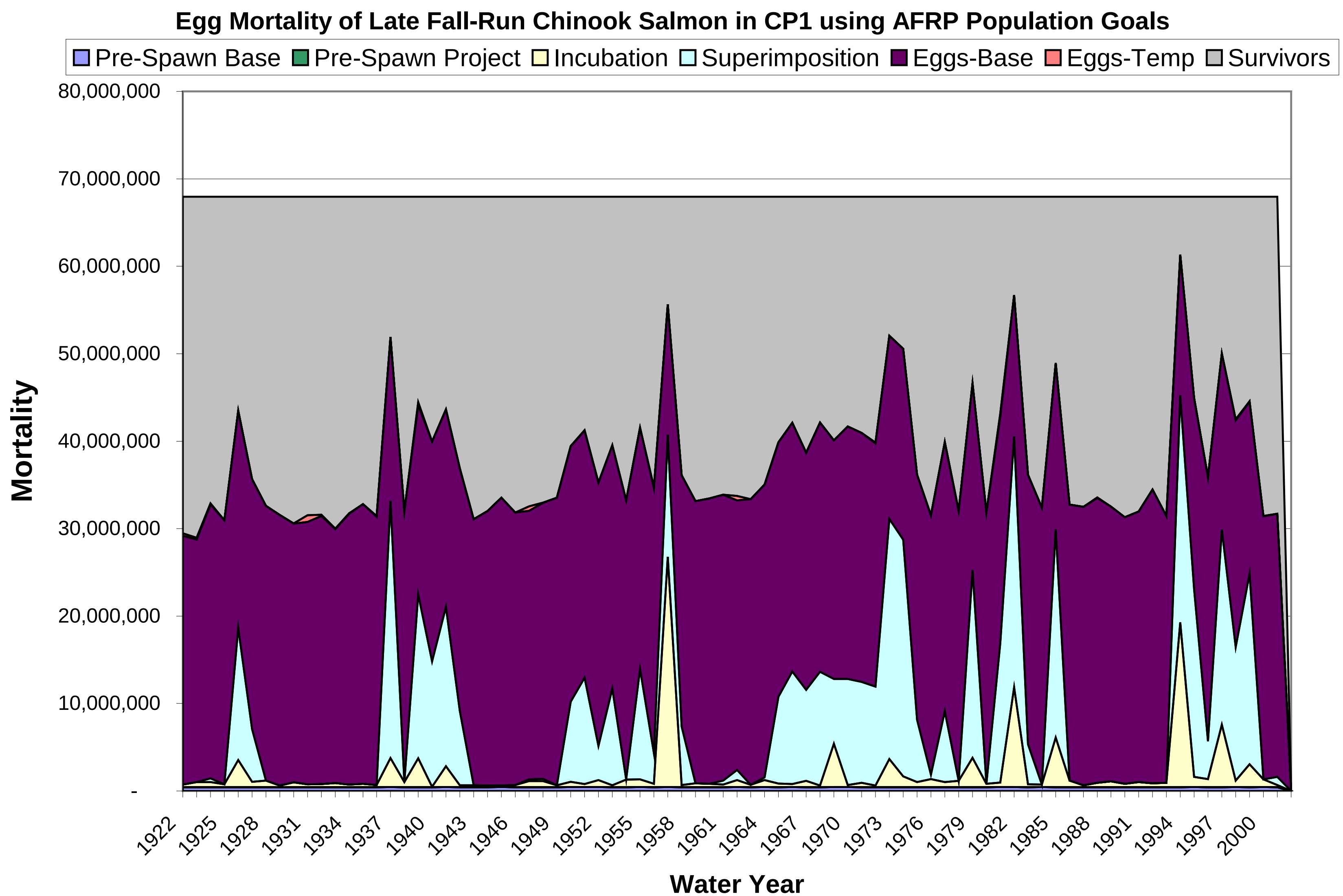

Figure B-52B. Source of mortality of late fall-run Chinook salmon eggs in CP1 based on the AFRP population goals.

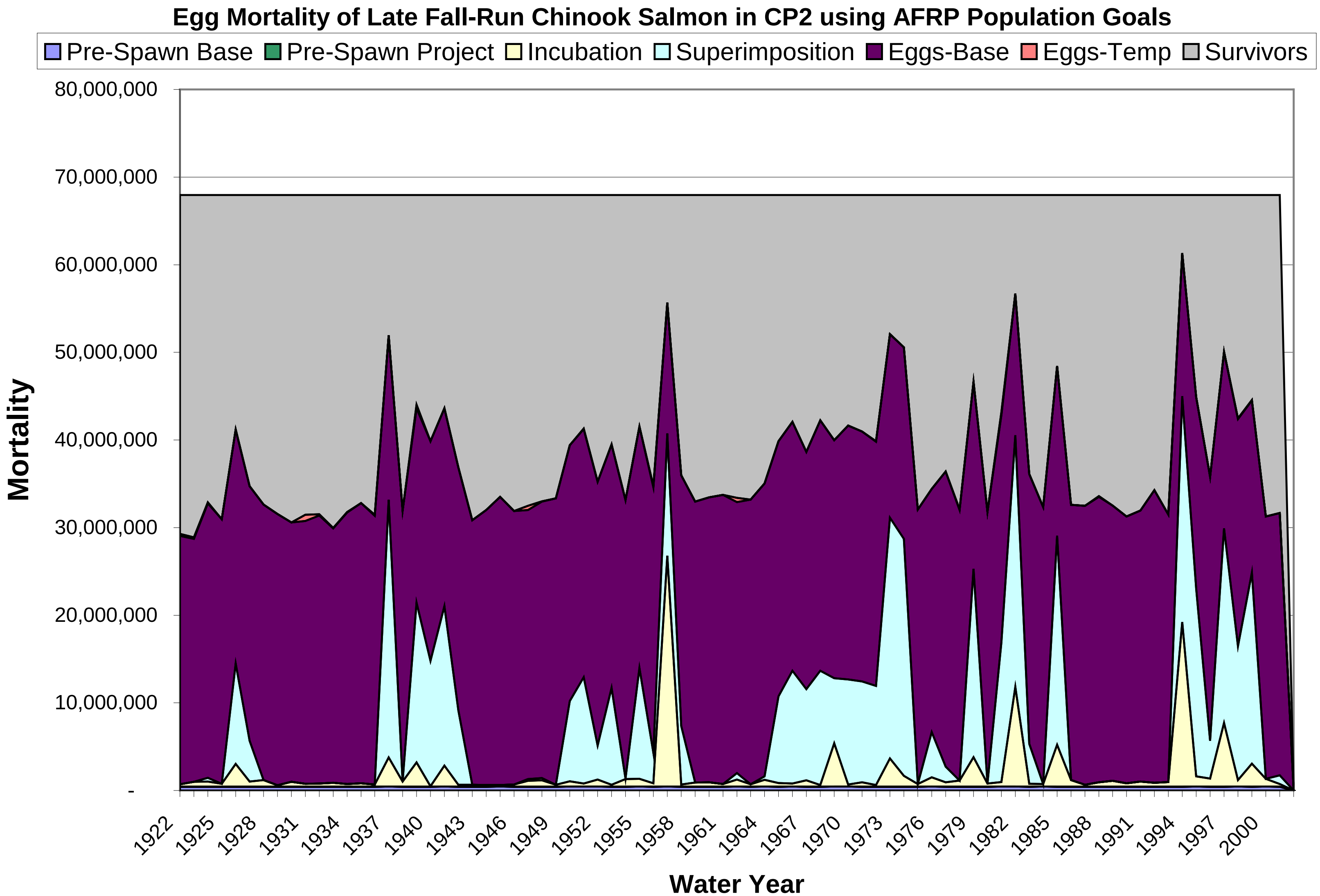

Figure B-52C. Source of mortality of late fall-run Chinook salmon eggs in CP2 based on the AFRP population goals.

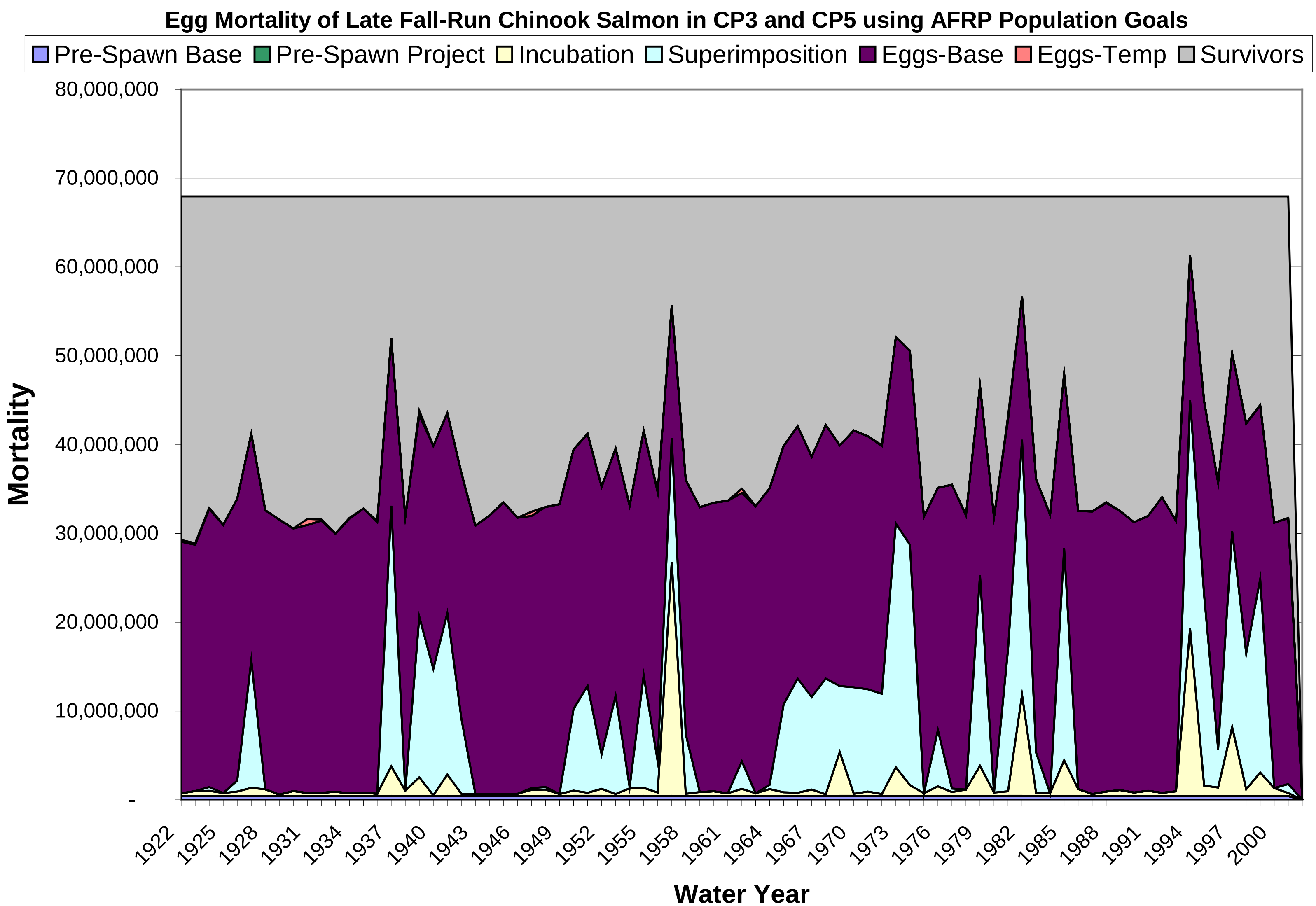

Figure B-52D. Source of mortality of late fall-run Chinook salmon eggs in CP3 and CP5 based on the AFRP population goals.

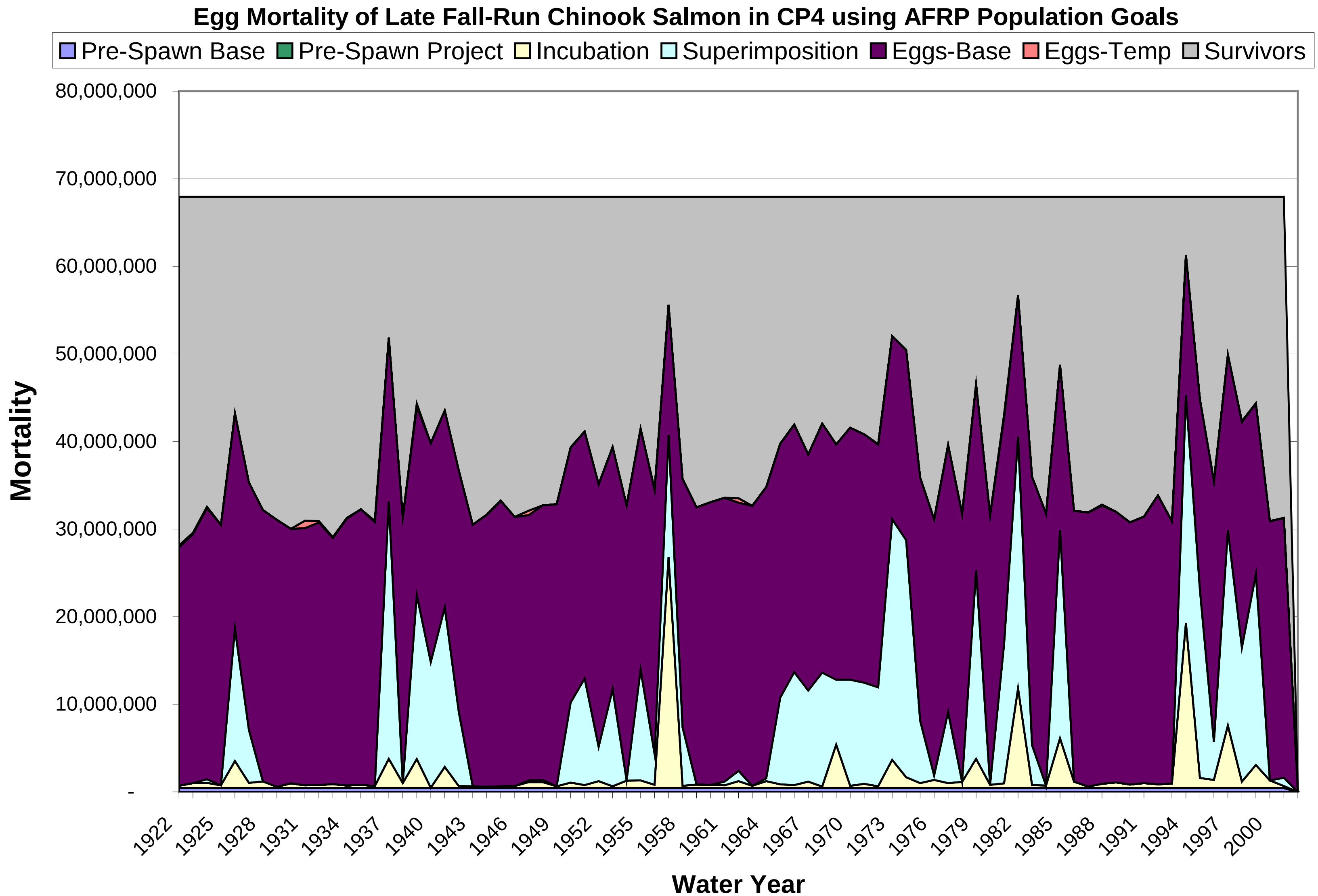

Figure B-52E. Source of mortality of late fall-run Chinook salmon eggs in CP4 based on the AFRP population goals.

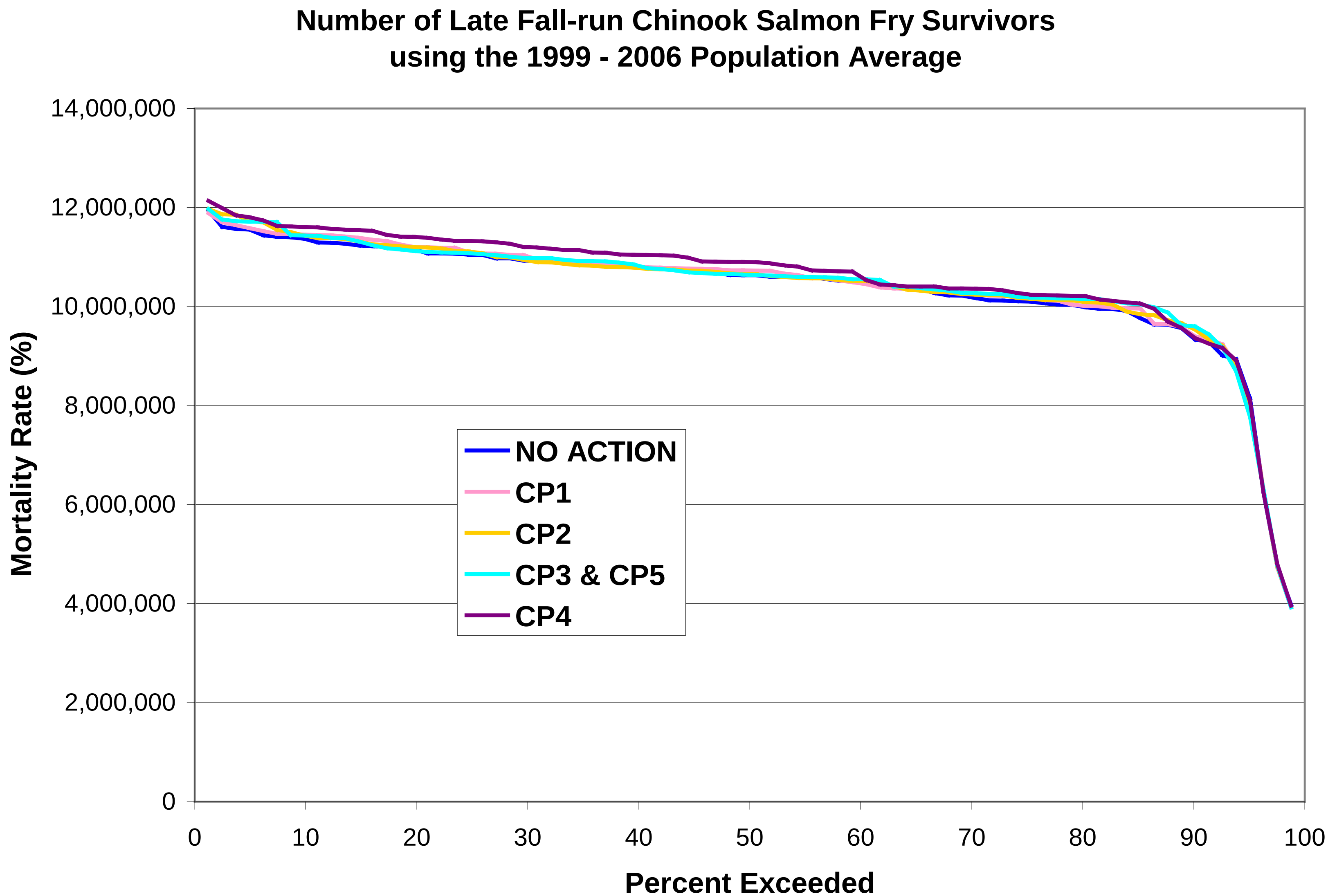

Figure B-53A. Frequency distribution of the number of late fall-run Chinook salmon fry survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

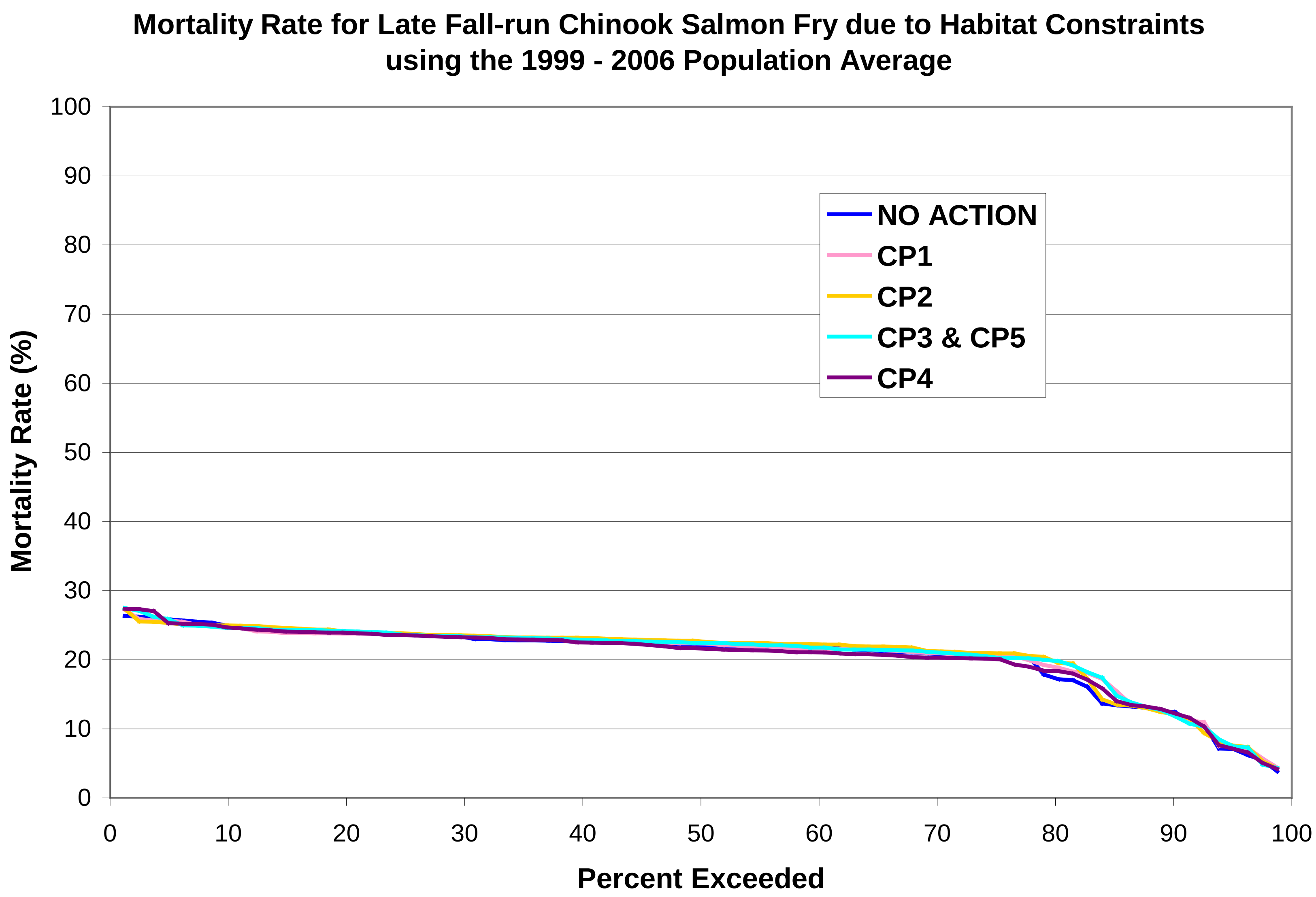

Figure B-53B. Frequency distribution of the mortality rate of late fall-run Chinook salmon fry due to habitat constraints (forced movement of fry due to flows or fish density) during the 1921-2003 simulation period based on the 1999-2006 population average.

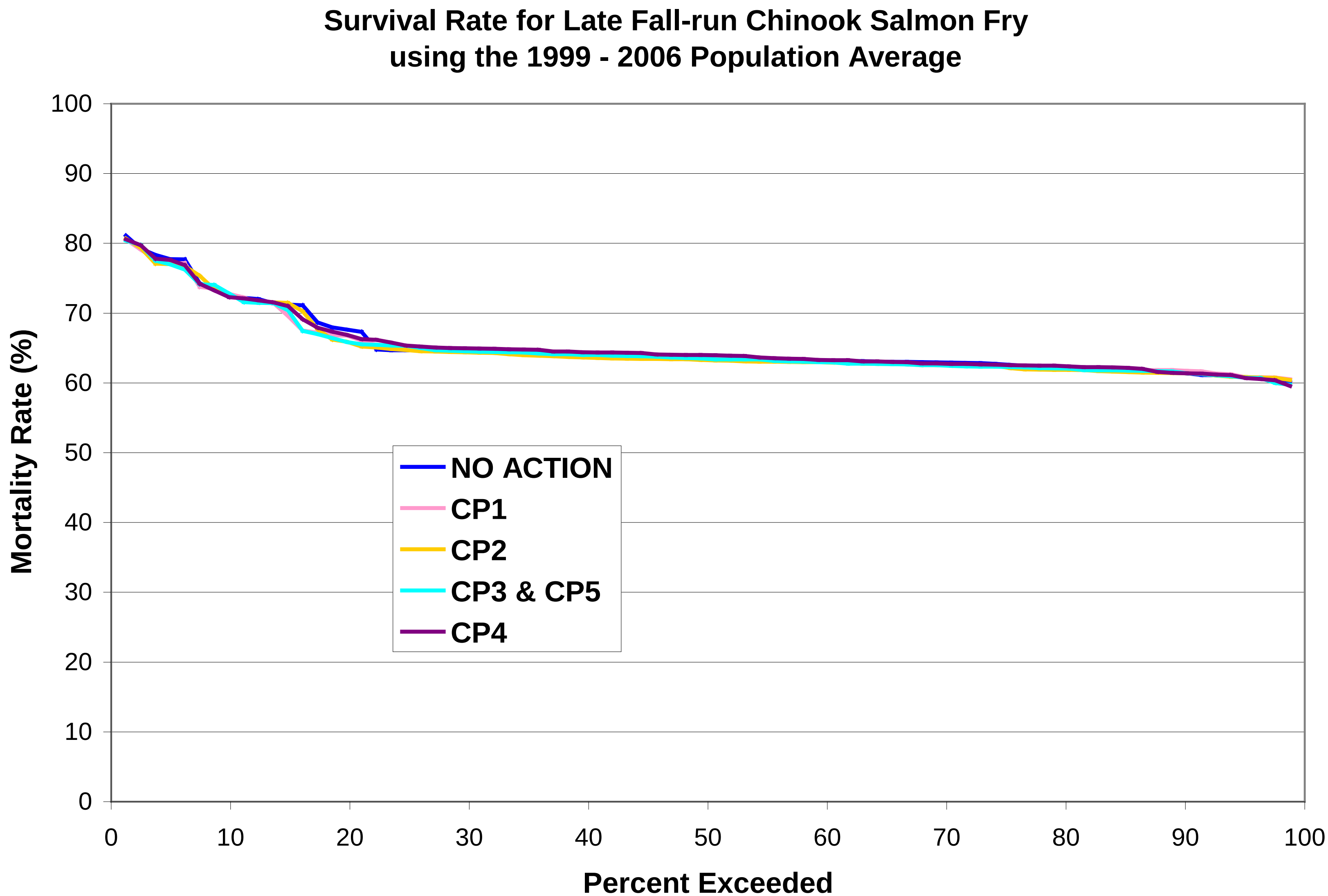

Figure B-53C. Frequency distribution of the survival rate of late fall-run Chinook salmon fry during the 1921-2003 simulation period based on the 1999-2006 population average.

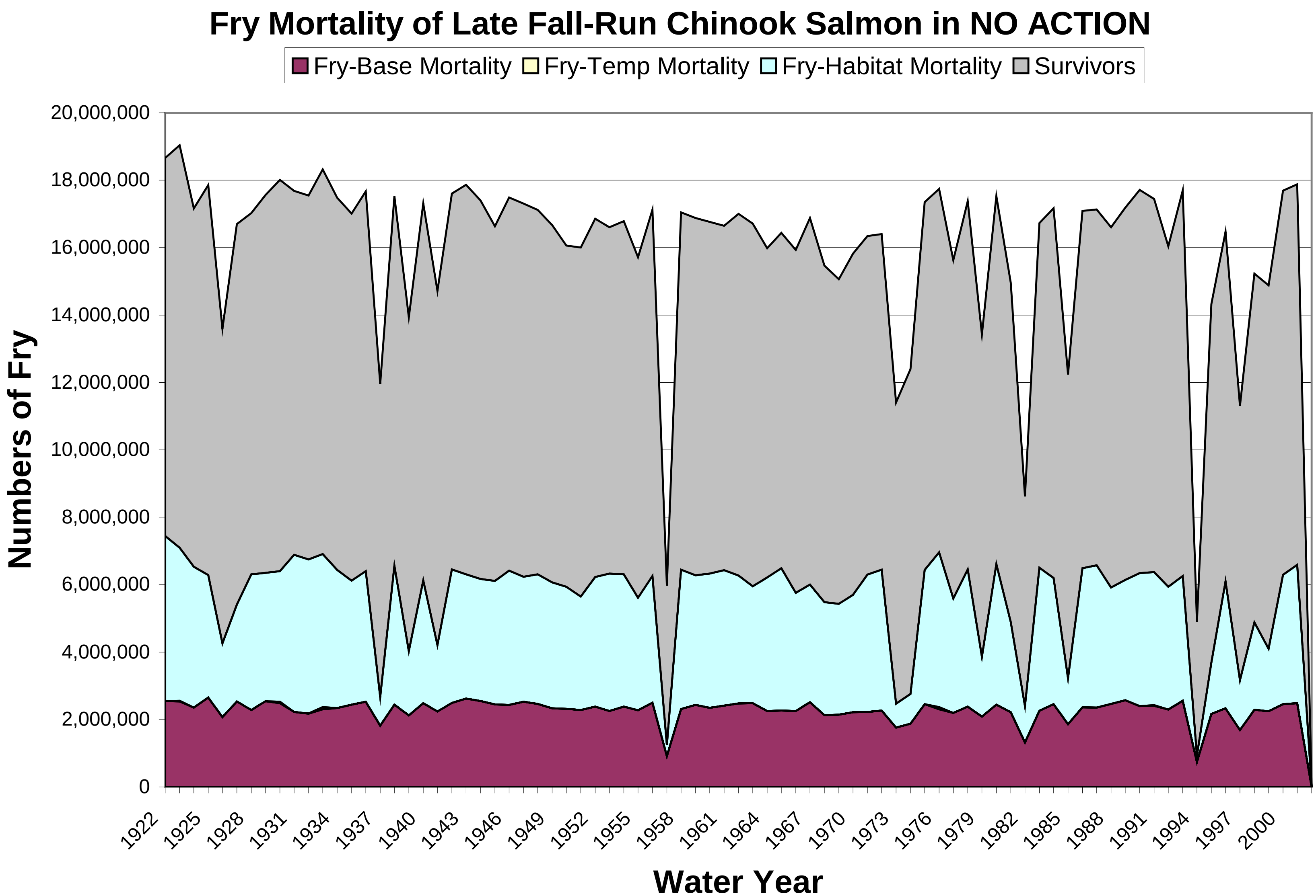

Figure B-54A. Source of mortality of late fall-run Chinook salmon fry in NO ACTION based on the 1999-2006 population average.

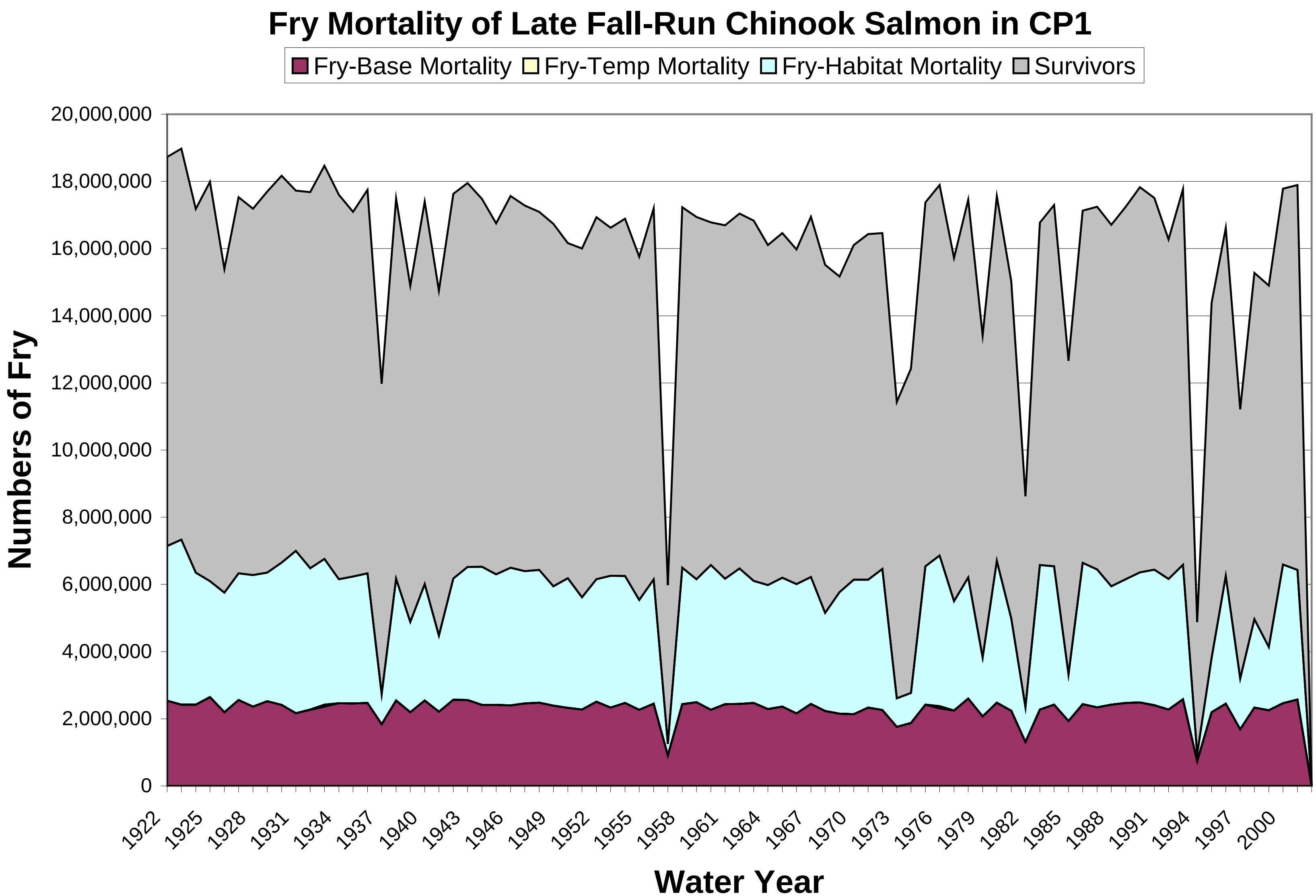

Figure B-54B. Source of mortality of late fall-run Chinook salmon fry in CP1 based on the 1999-2006 population average.

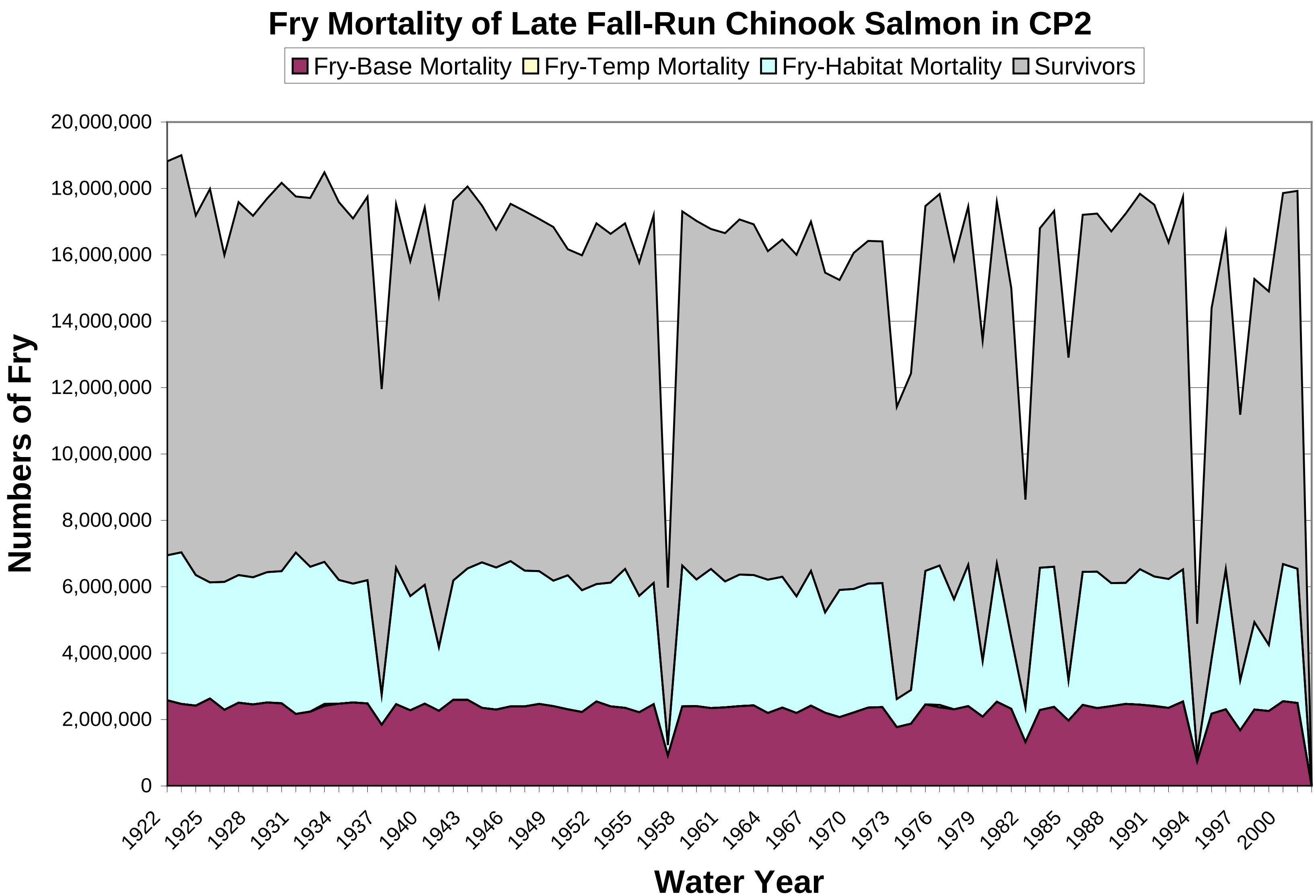

Figure B-54C. Source of mortality of late fall-run Chinook salmon fry in CP2 based on the 1999-2006 population average.

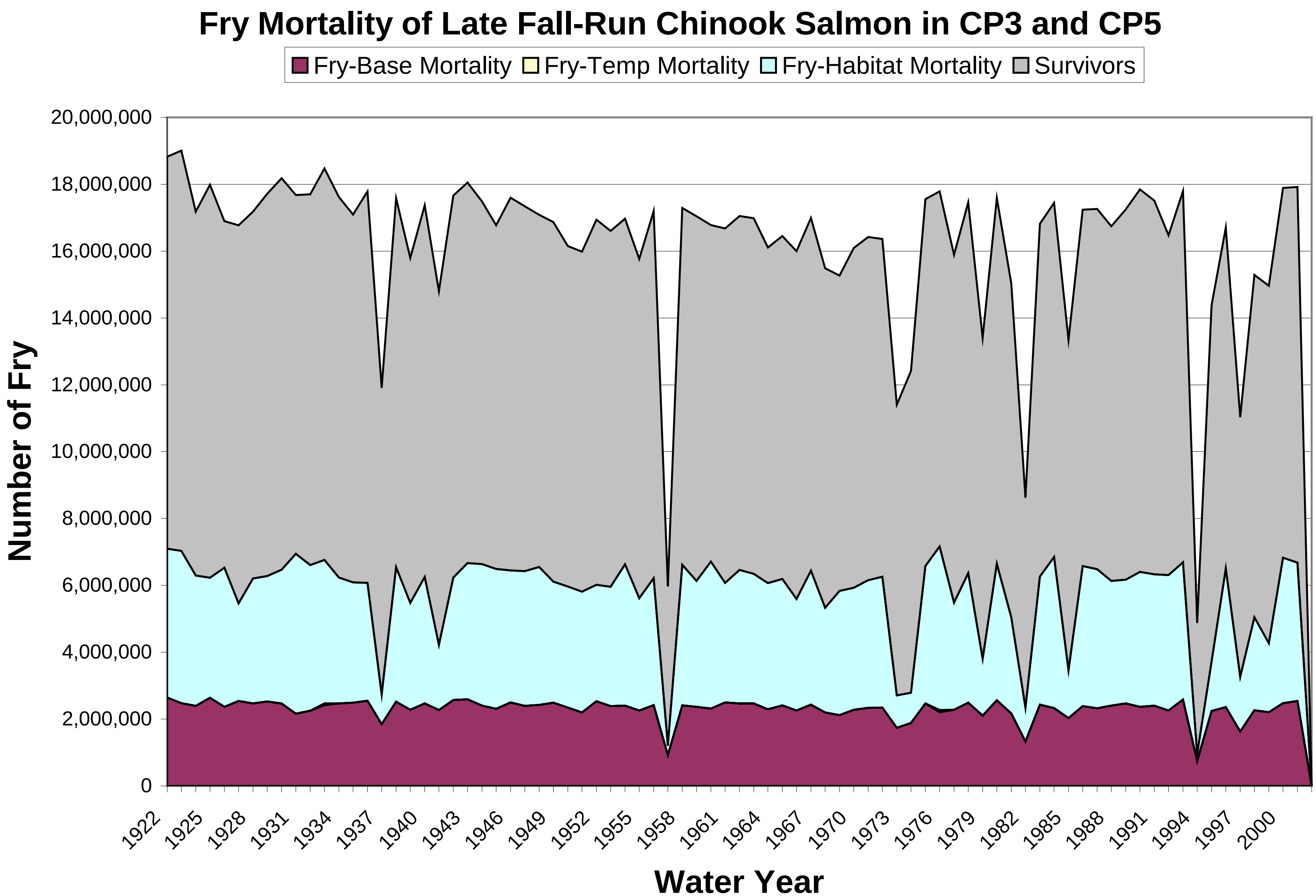

Figure B-54D. Source of mortality of late fall-run Chinook salmon fry in CP3 and CP5 based on the 1999-2006 population average.

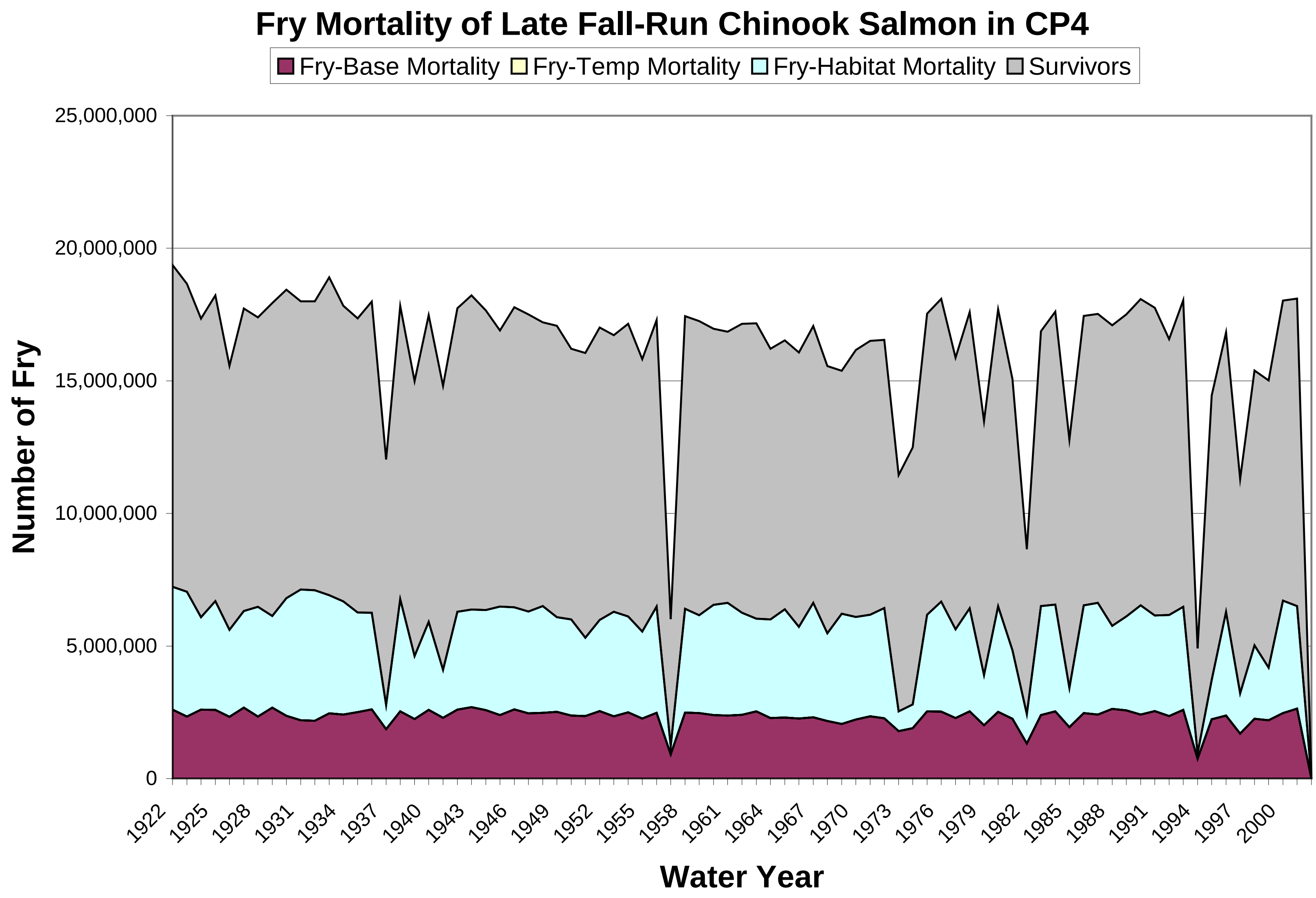

Figure B-54E. Source of mortality of late fall-run Chinook salmon fry in CP4 based on the 1999-2006 population average.

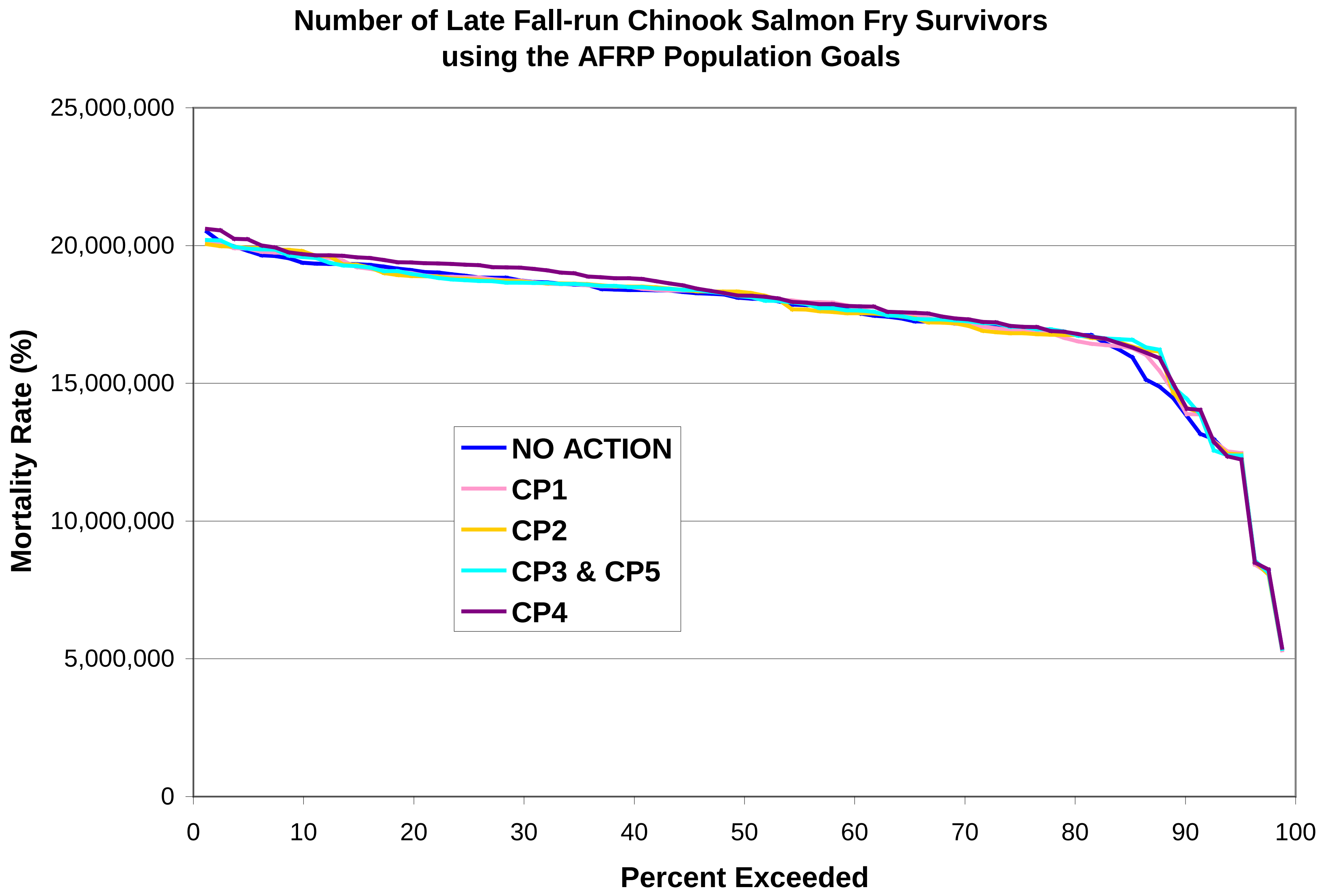

Figure B-55A. Frequency distribution of the number of late fall-run Chinook salmon fry survivors during the 1921-2003 simulation period based on the AFRP population goals.

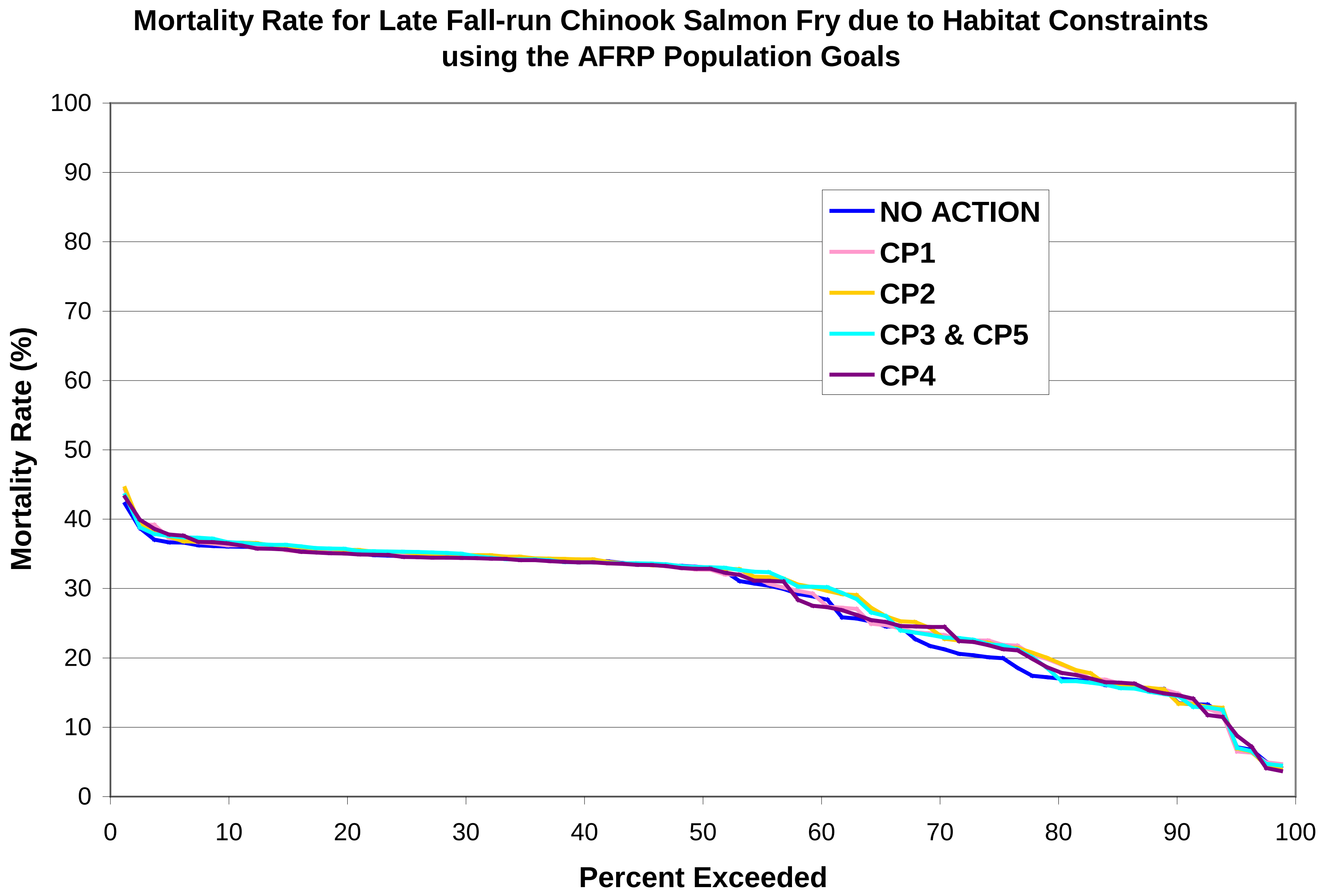

Figure B-55B. Frequency distribution of the mortality rate of late fall-run Chinook salmon fry due to habitat constraints (forced movement of fry due to flows or fish density) during the 1921-2003 simulation period based on the AFRP population goals.

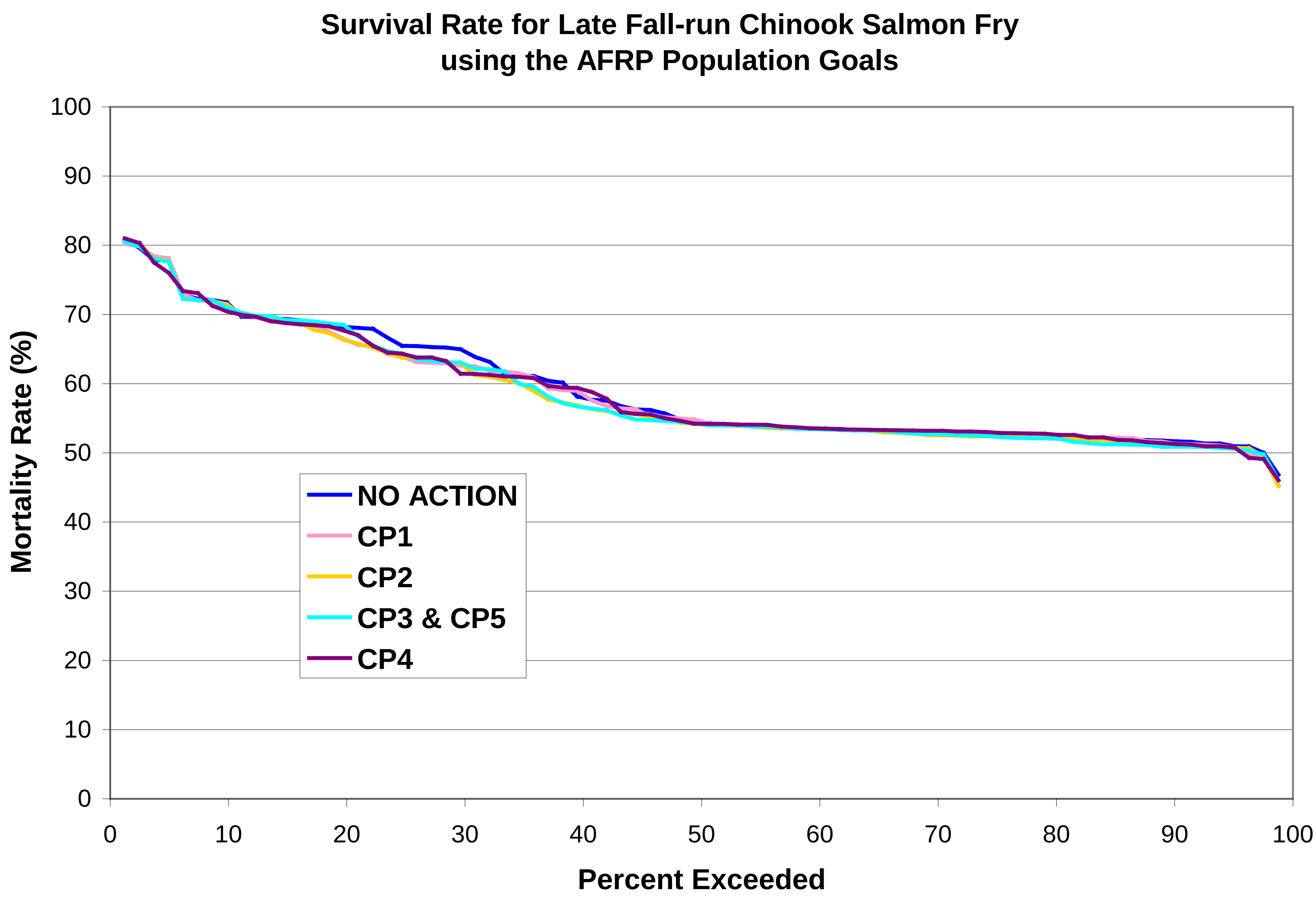

Figure B-55C. Frequency distribution of the survival rate of late fall-run Chinook salmon fry during the 1921-2003 simulation period based on the AFRP population goals.

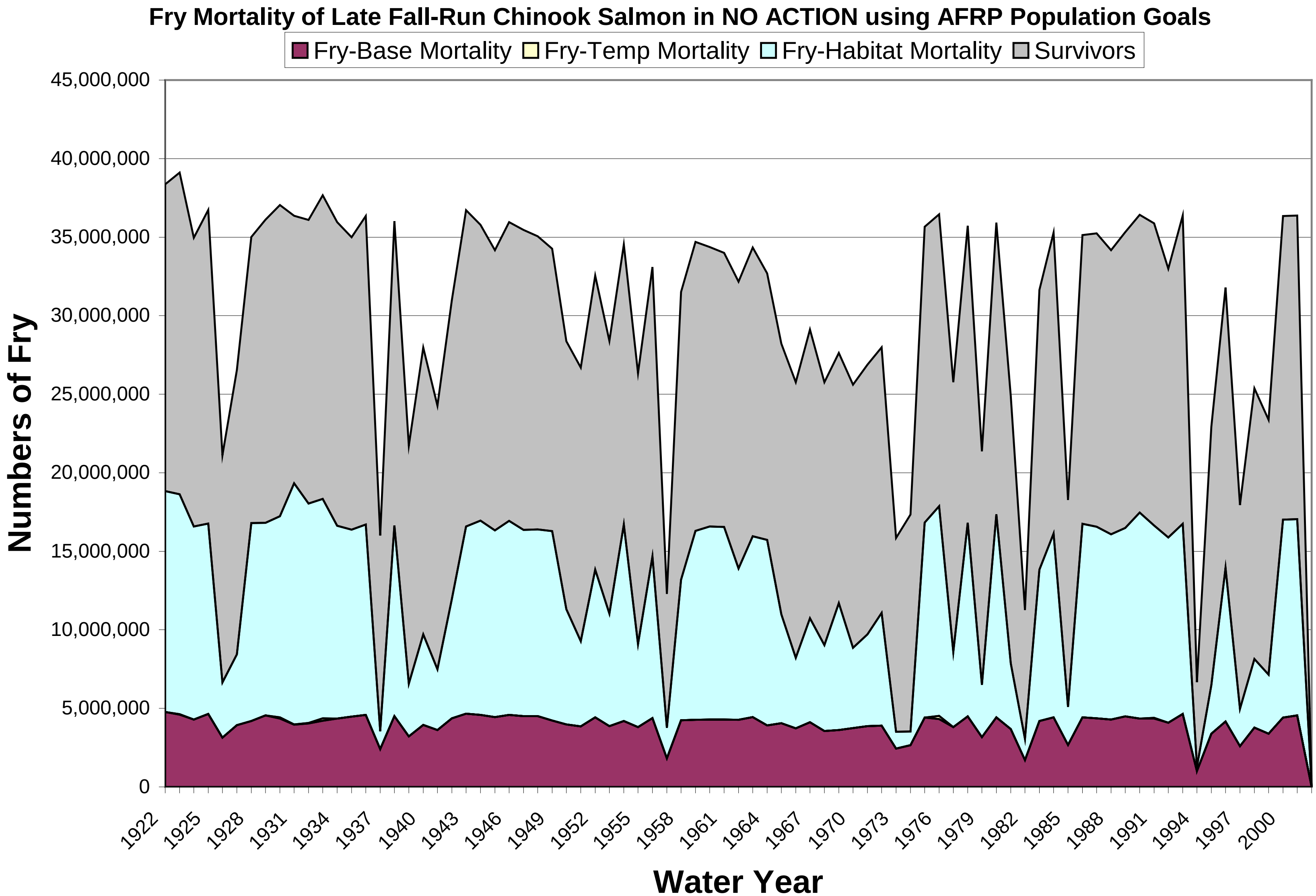

Figure B-56A. Source of mortality of late fall-run Chinook salmon fry in NO ACTION based on the AFRP population goals.

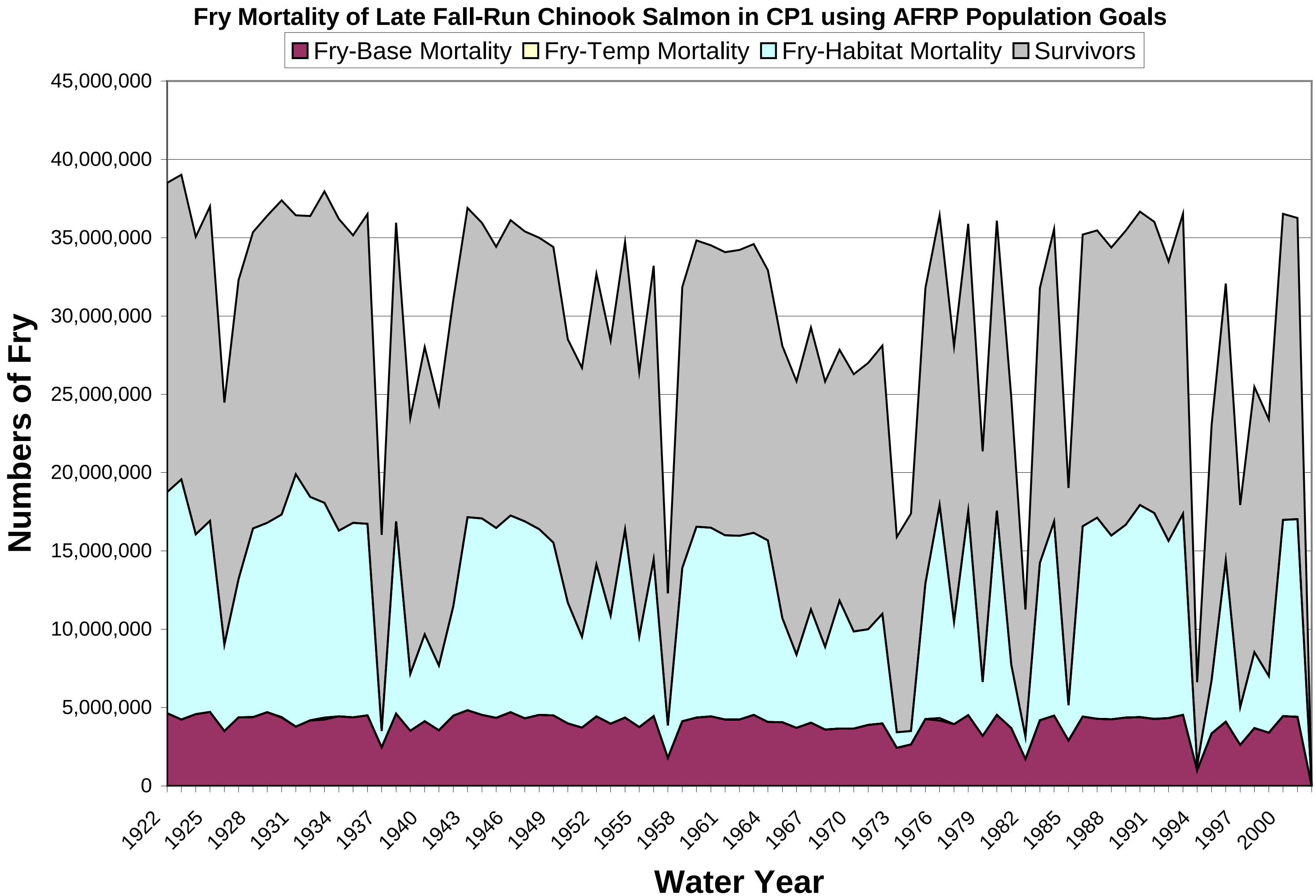

Figure B-56B. Source of mortality of late fall-run Chinook salmon fry in CP1 based on the AFRP population goals.

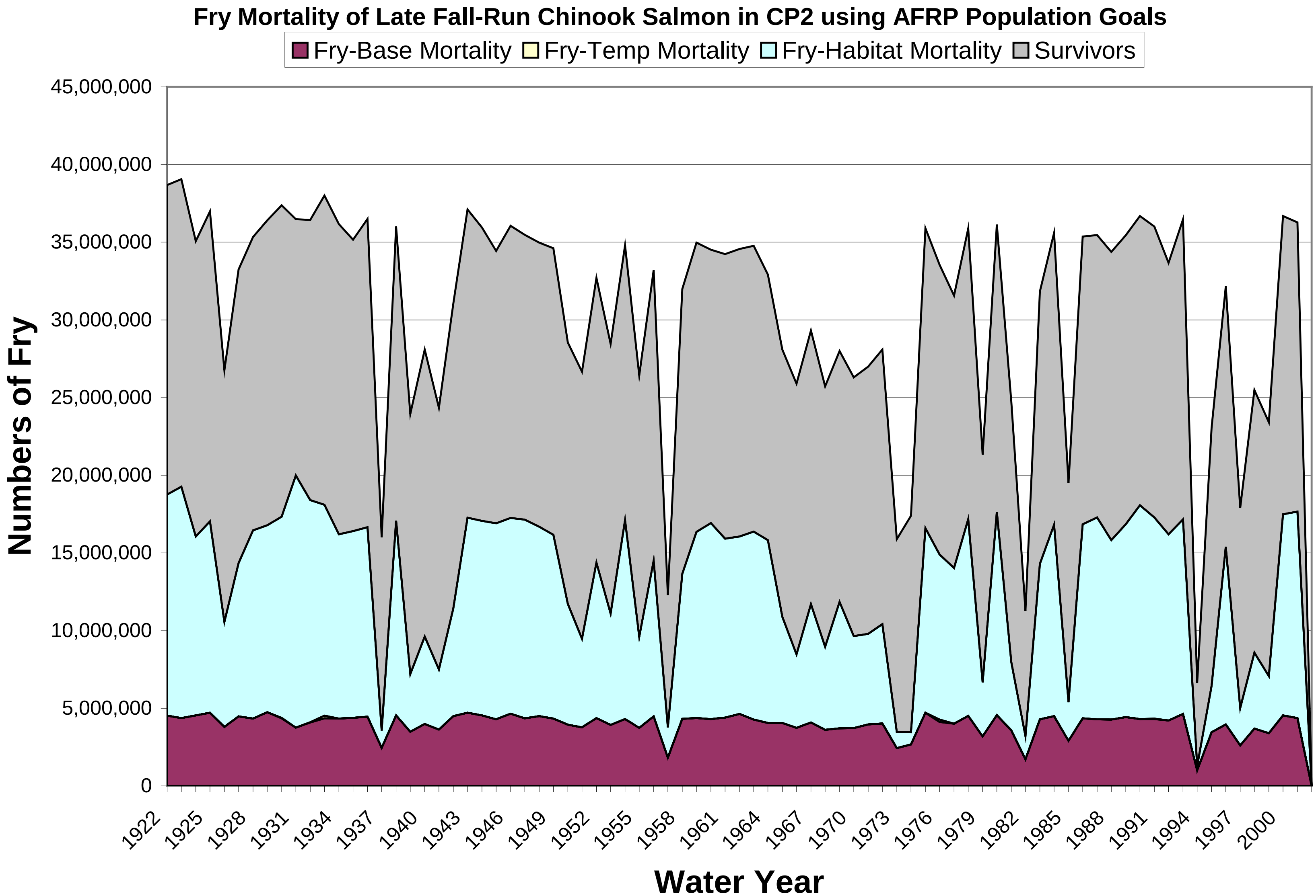

Figure B-56C. Source of mortality of late fall-run Chinook salmon fry in CP2 based on the AFRP population goals.

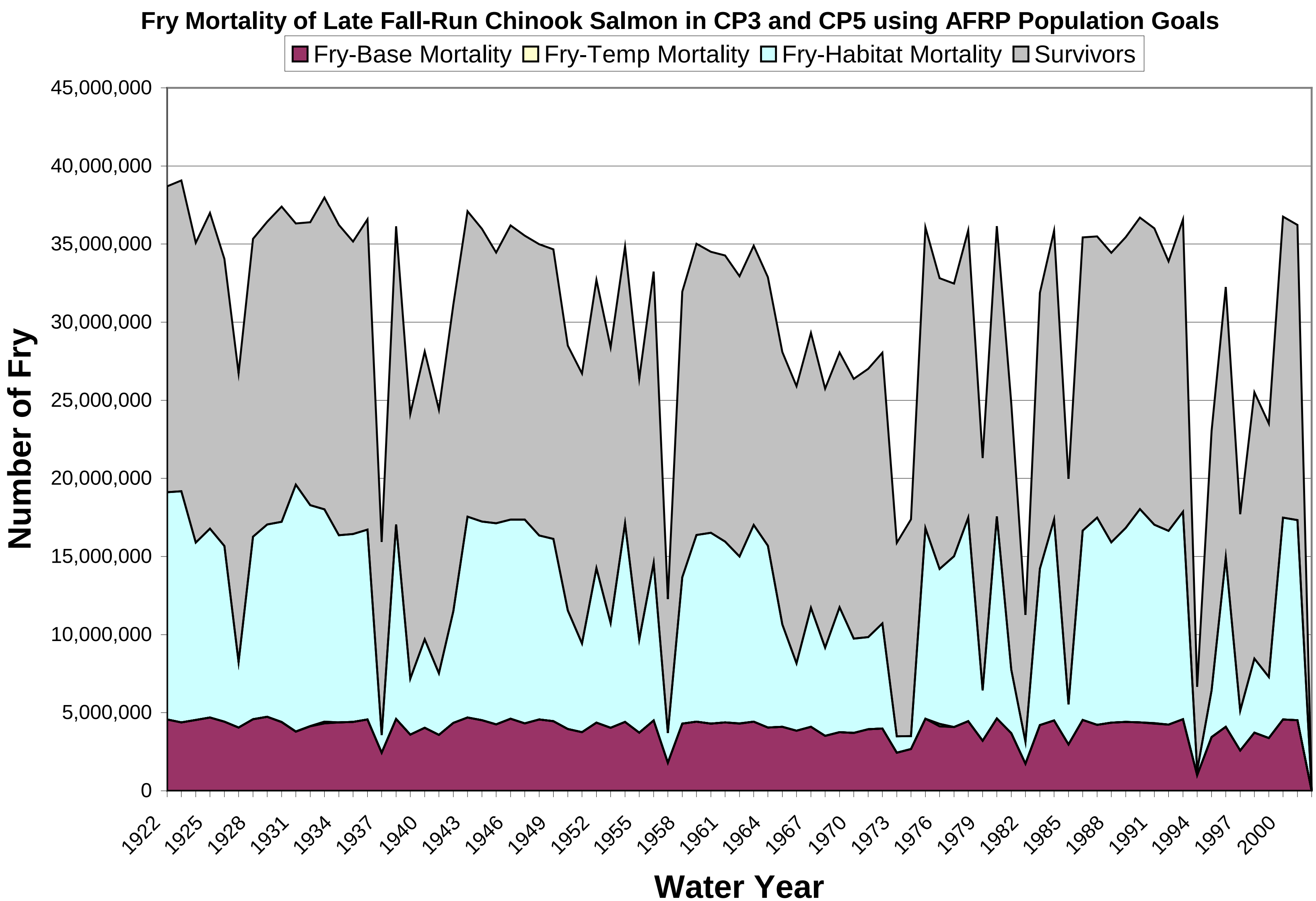

Figure B-56D. Source of mortality of late fall-run Chinook salmon fry in CP3 and CP5 based on the AFRP population goals.

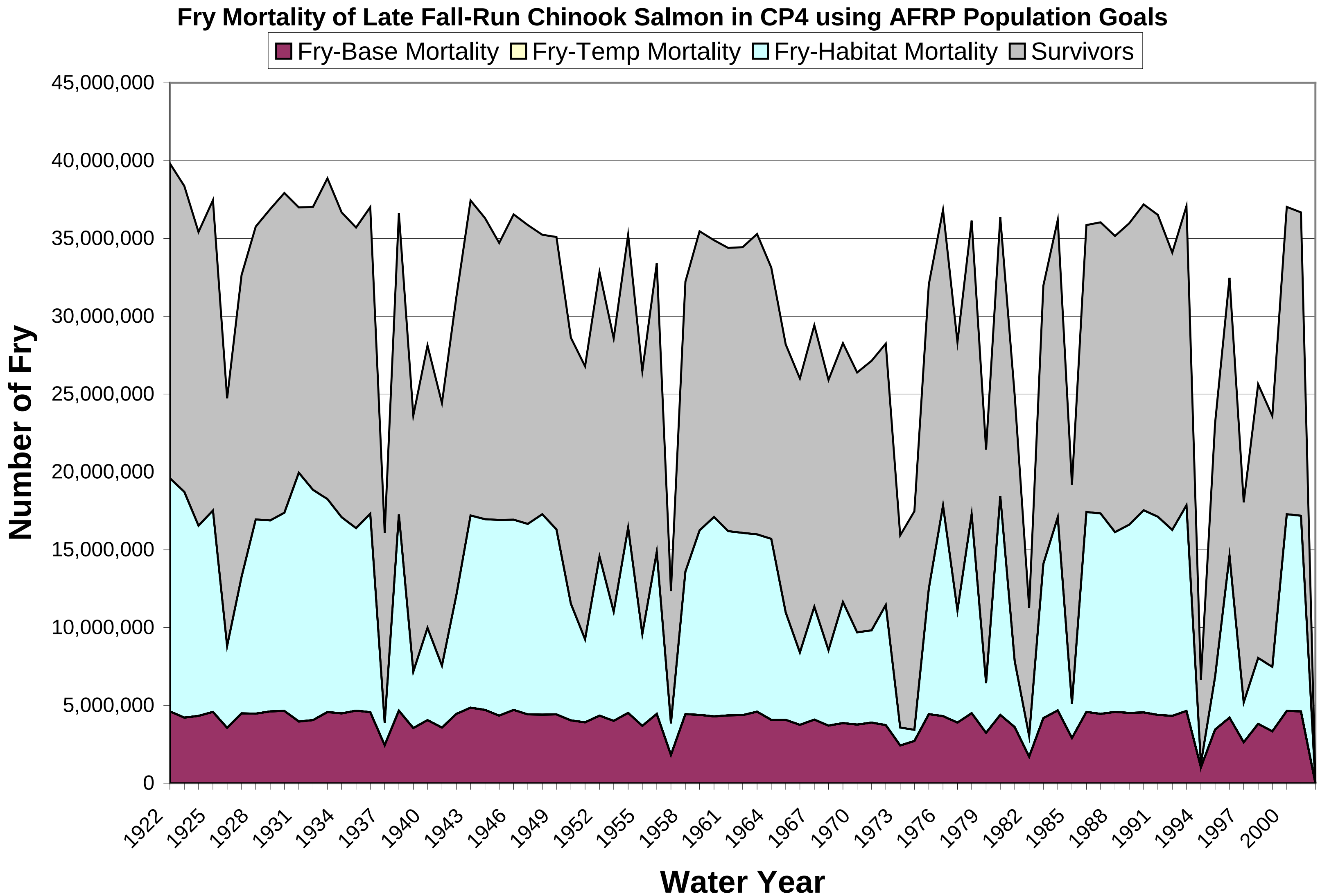

Figure B-56E. Source of mortality of late fall-run Chinook salmon fry in CP4 based on the AFRP population goals.

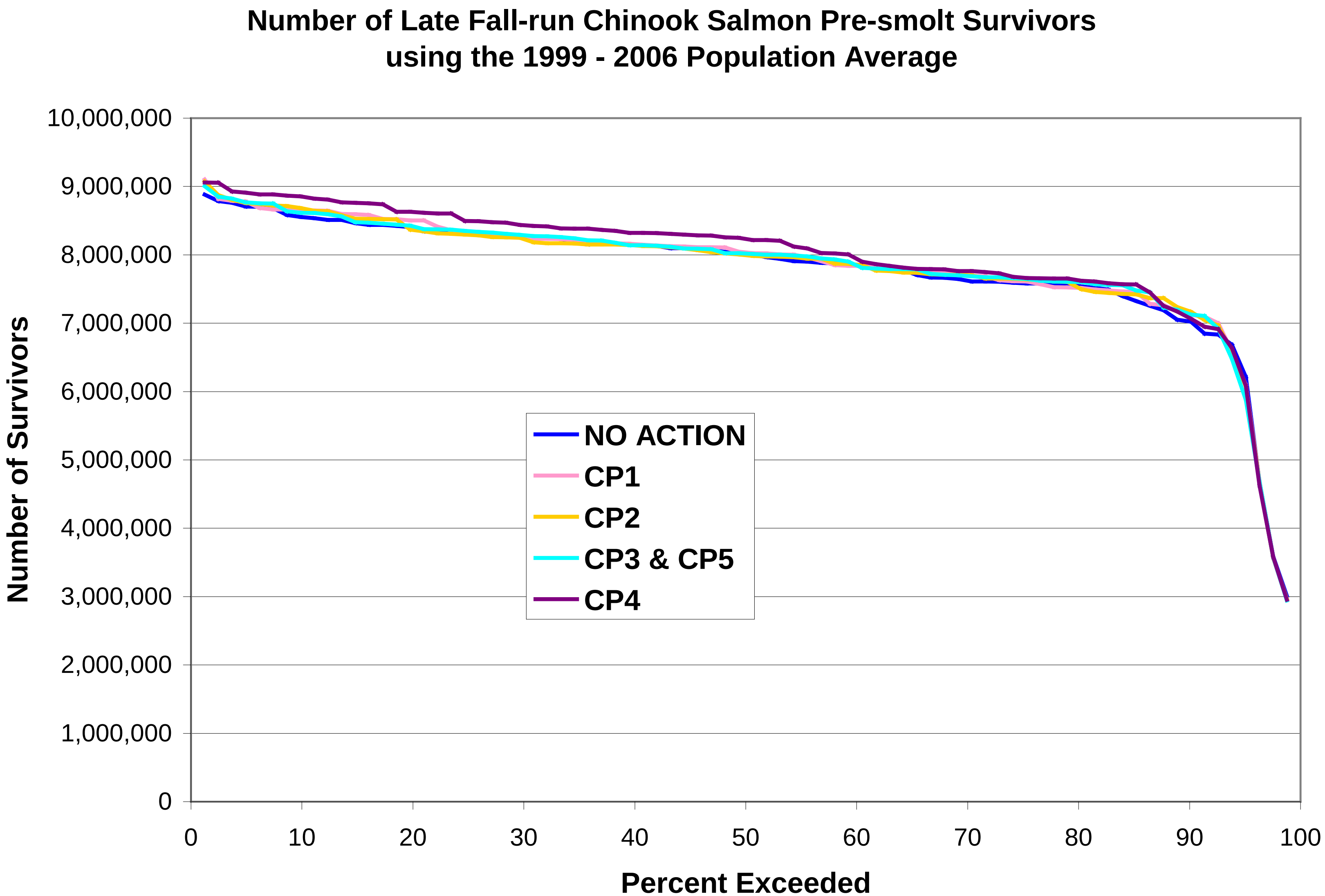

Figure B-57A. Frequency distribution of the number of late fall-run Chinook salmon pre-smolt survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

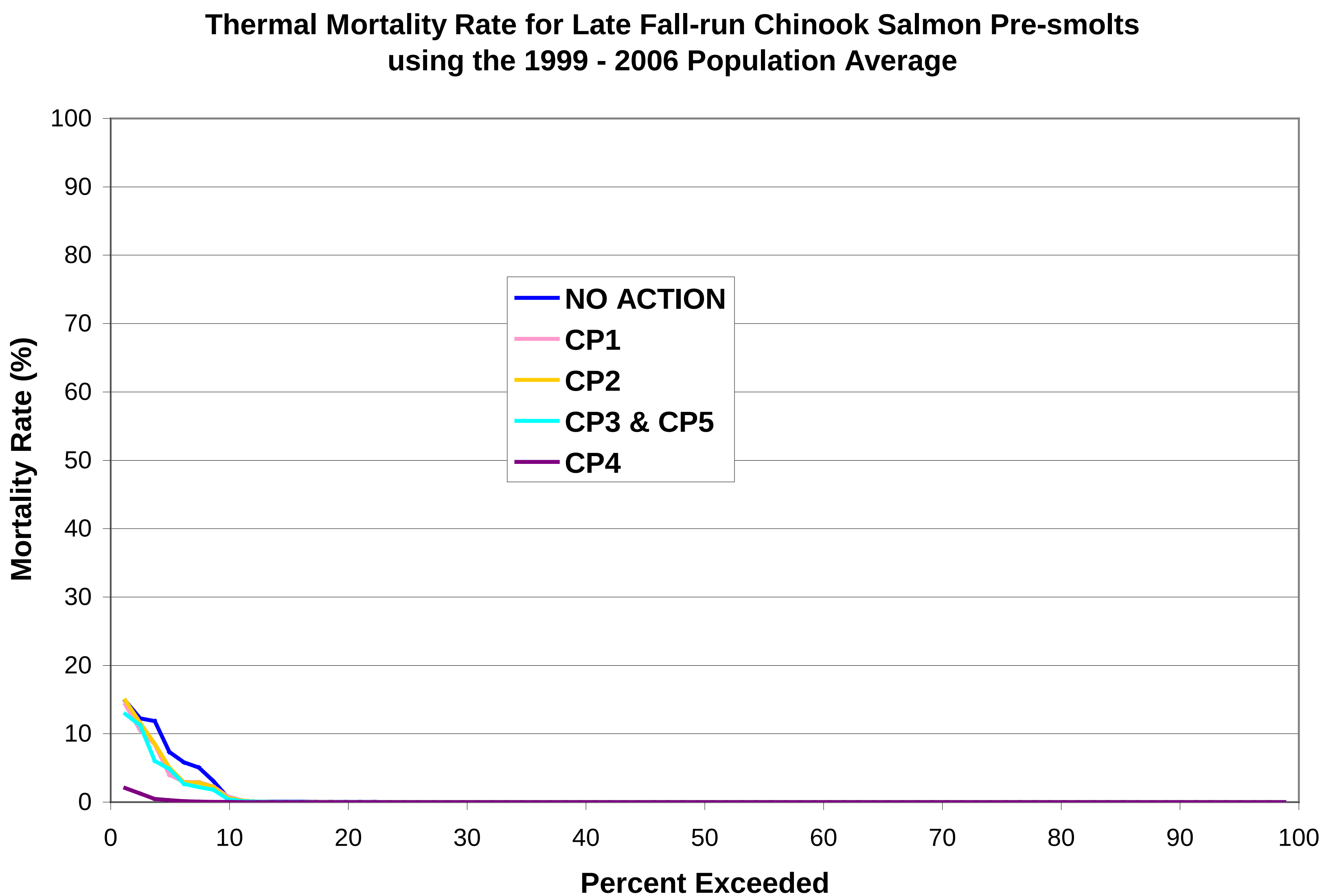

Figure B-57B. Frequency distribution of the thermal mortality rate of late fall-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the 1999-2006 population average.

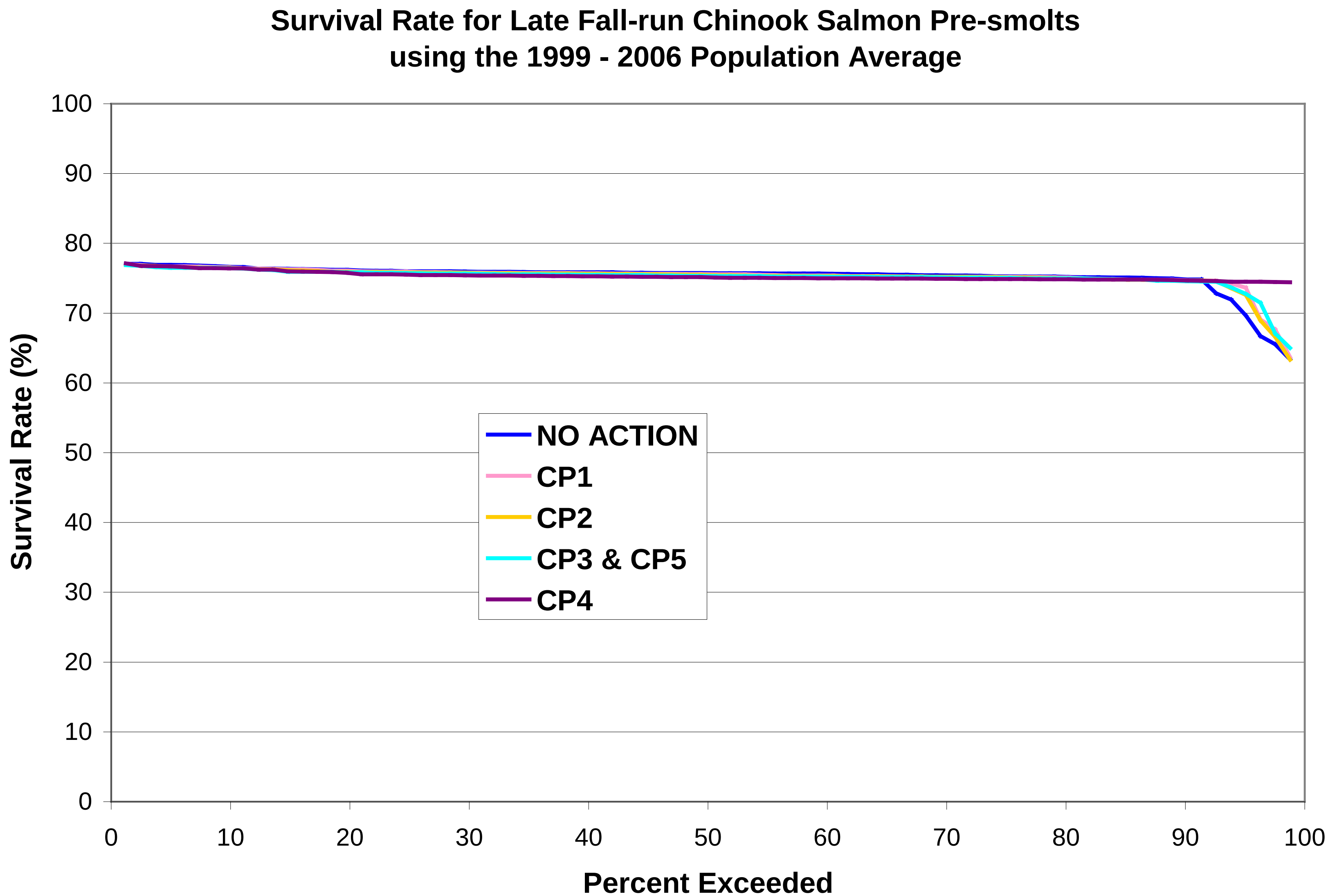

Figure B-57C. Frequency distribution of the survival rate of late fall-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the 1999-2006 population average.

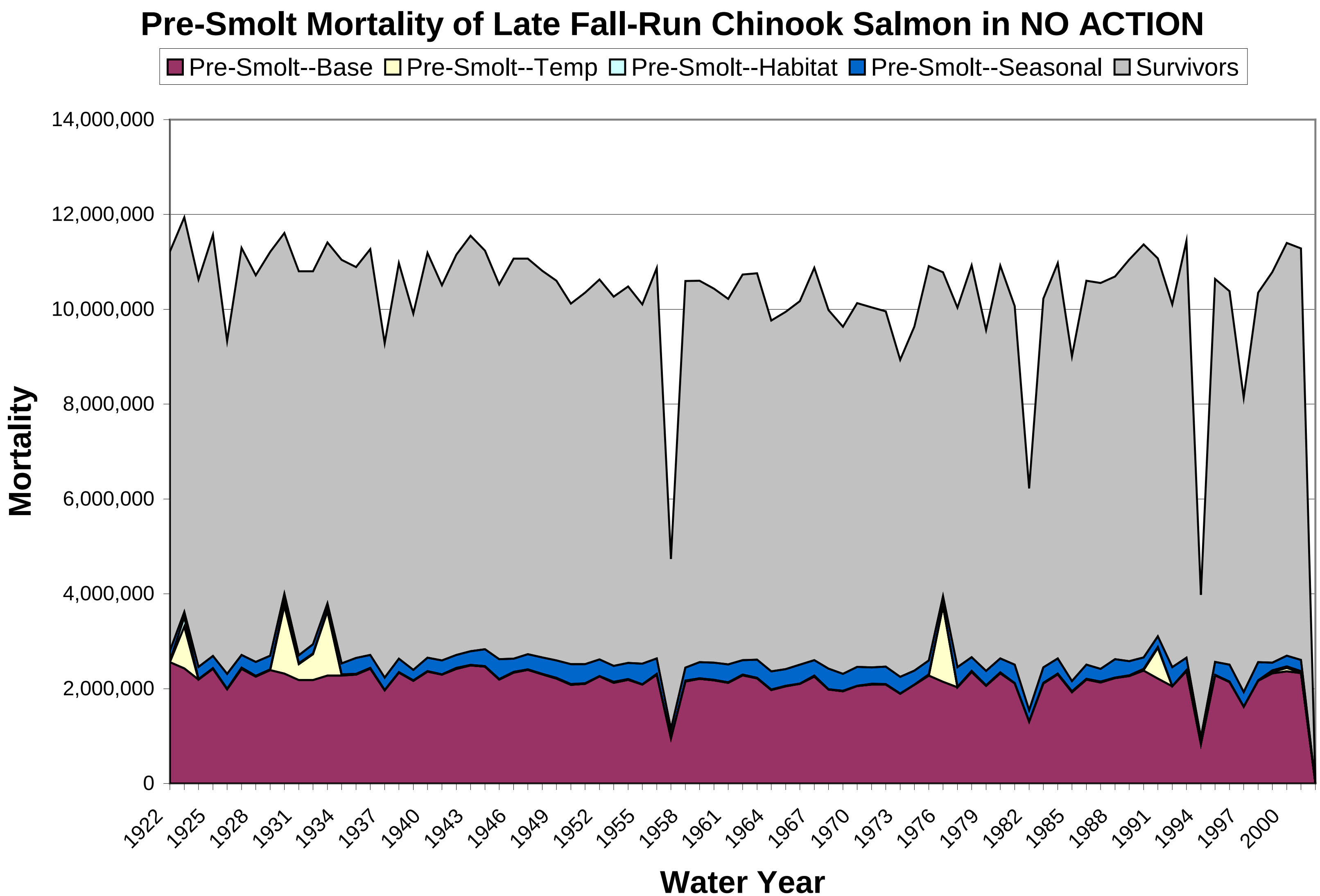

Figure B-58A. Source of mortality of late fall-run Chinook salmon pre-smolts in NO ACTION based on the 1999-2006 population average.

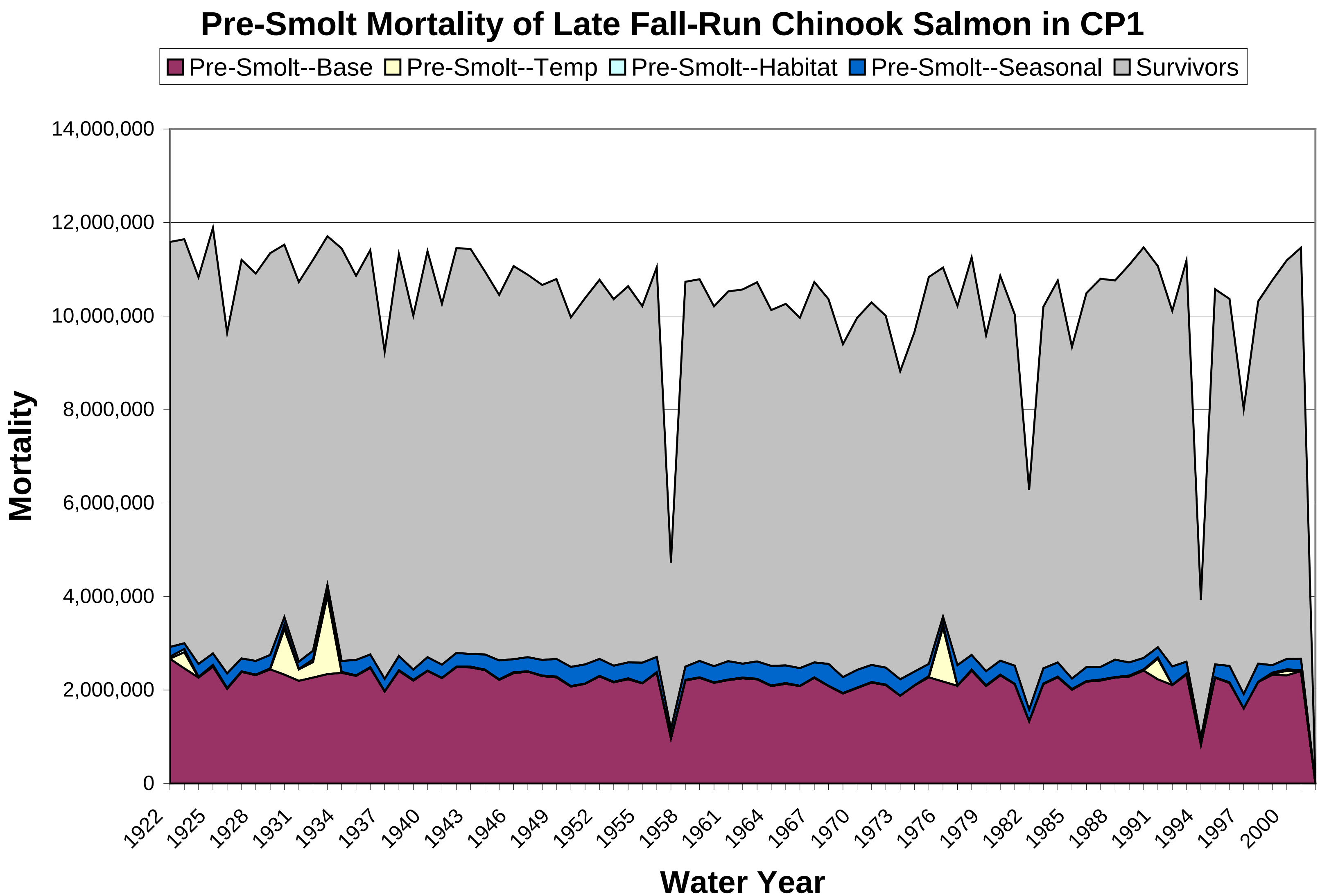

Figure B-58B. Source of mortality of late fall-run Chinook salmon pre-smolts in CP1 based on the 1999-2006 population average.

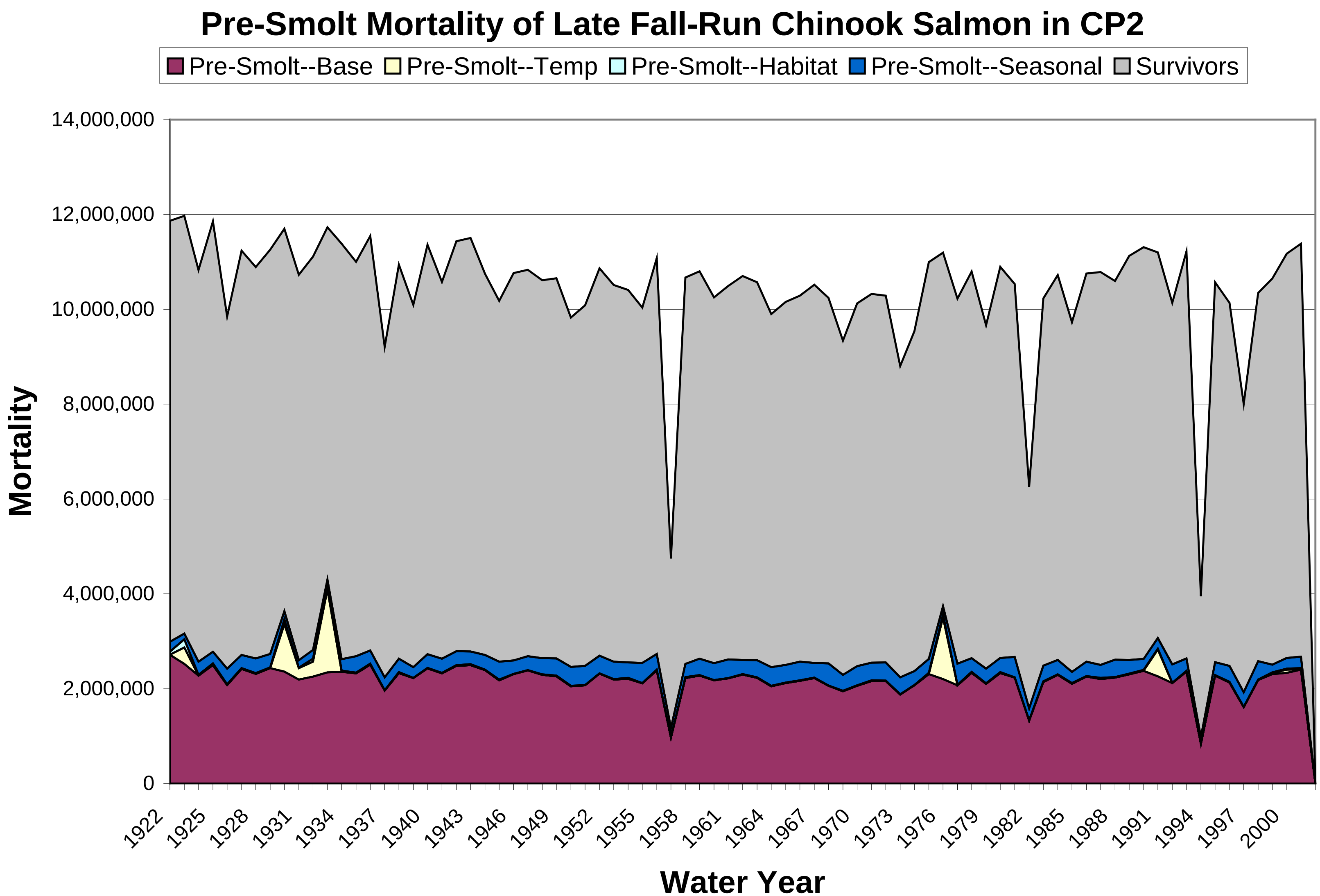

Figure B-58C. Source of mortality of late fall-run Chinook salmon pre-smolts in CP2 based on the 1999-2006 population average.

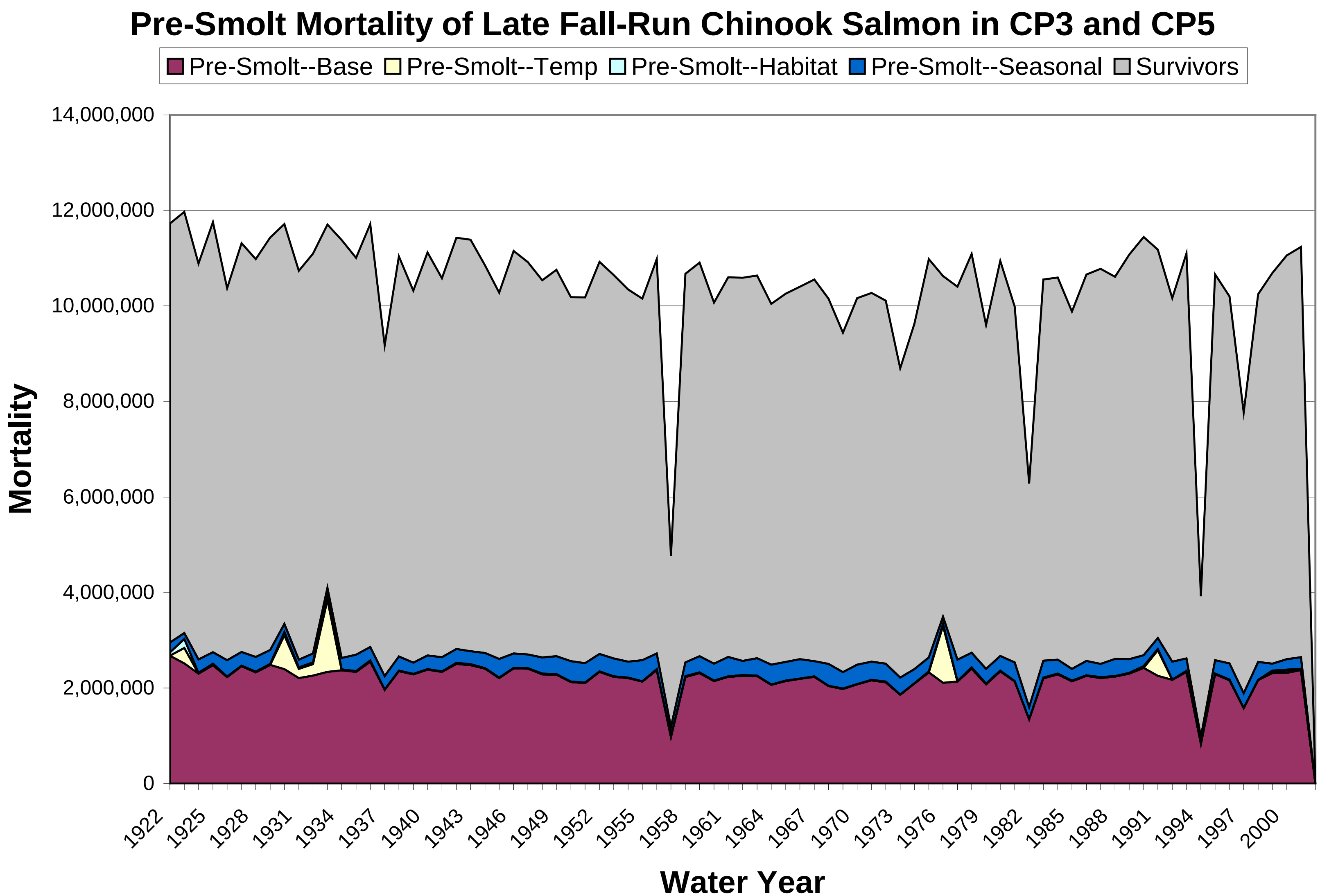

Figure B-58D. Source of mortality of late fall-run Chinook salmon pre-smolts in CP3 and CP5 based on the 1999-2006 population average.

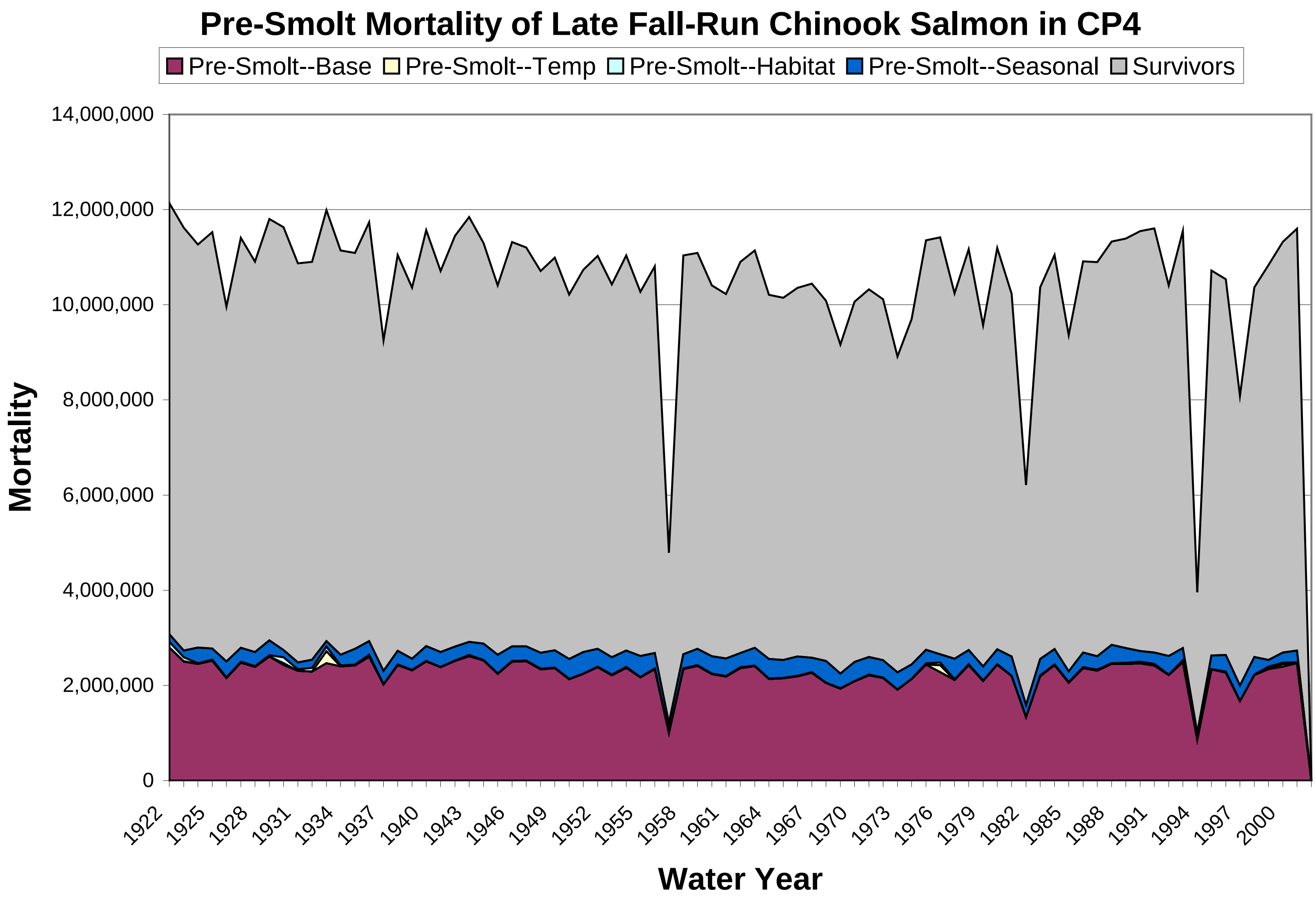

Figure B-58E. Source of mortality of late fall-run Chinook salmon pre-smolts in CP4 based on the 1999-2006 population average.

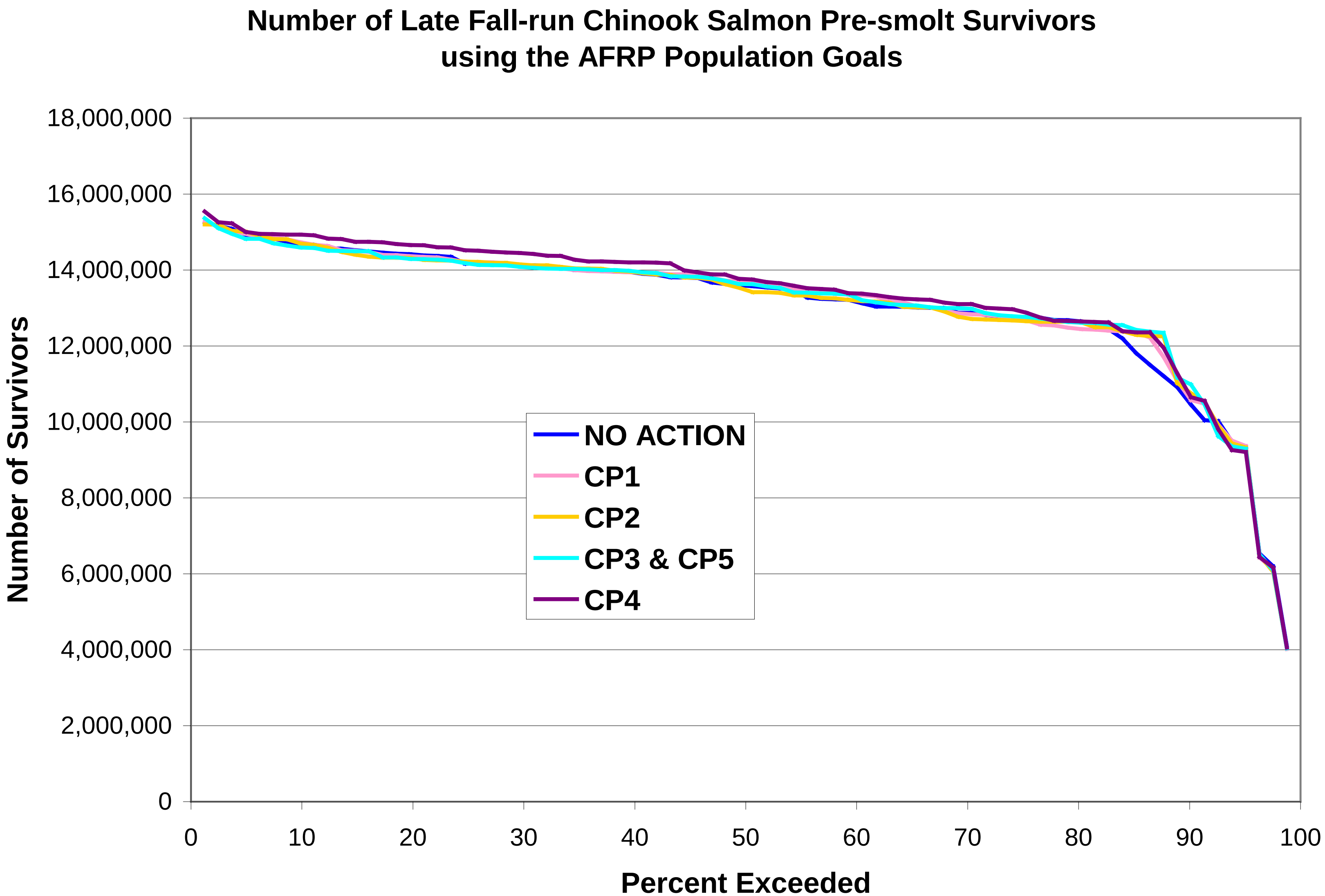

Figure B-59A. Frequency distribution of the number of late fall-run Chinook salmon pre-smolt survivors during the 1921-2003 simulation period based on the AFRP population goals.

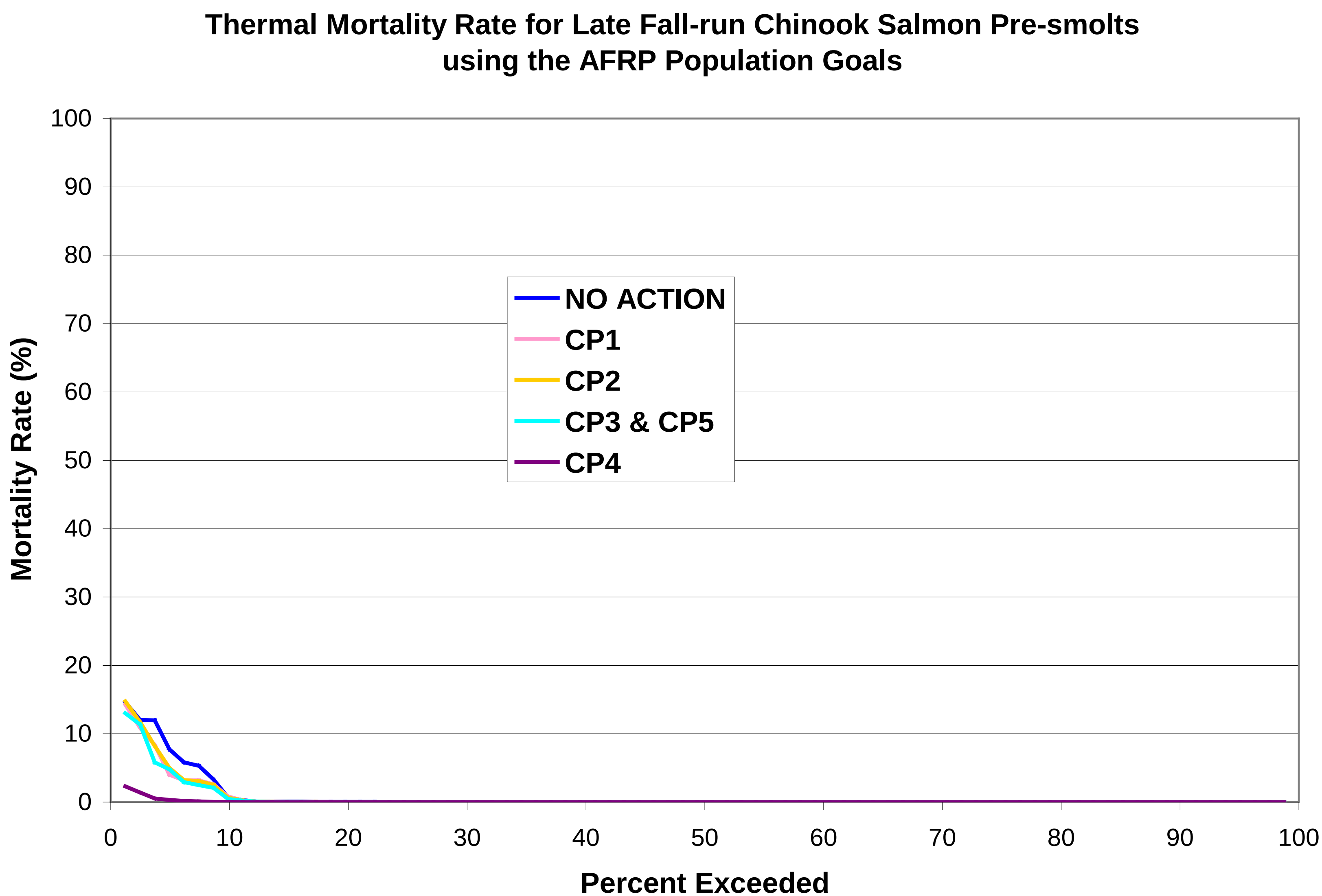

Figure B-59B. Frequency distribution of the thermal mortality rate of late fall-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the AFRP population goals.

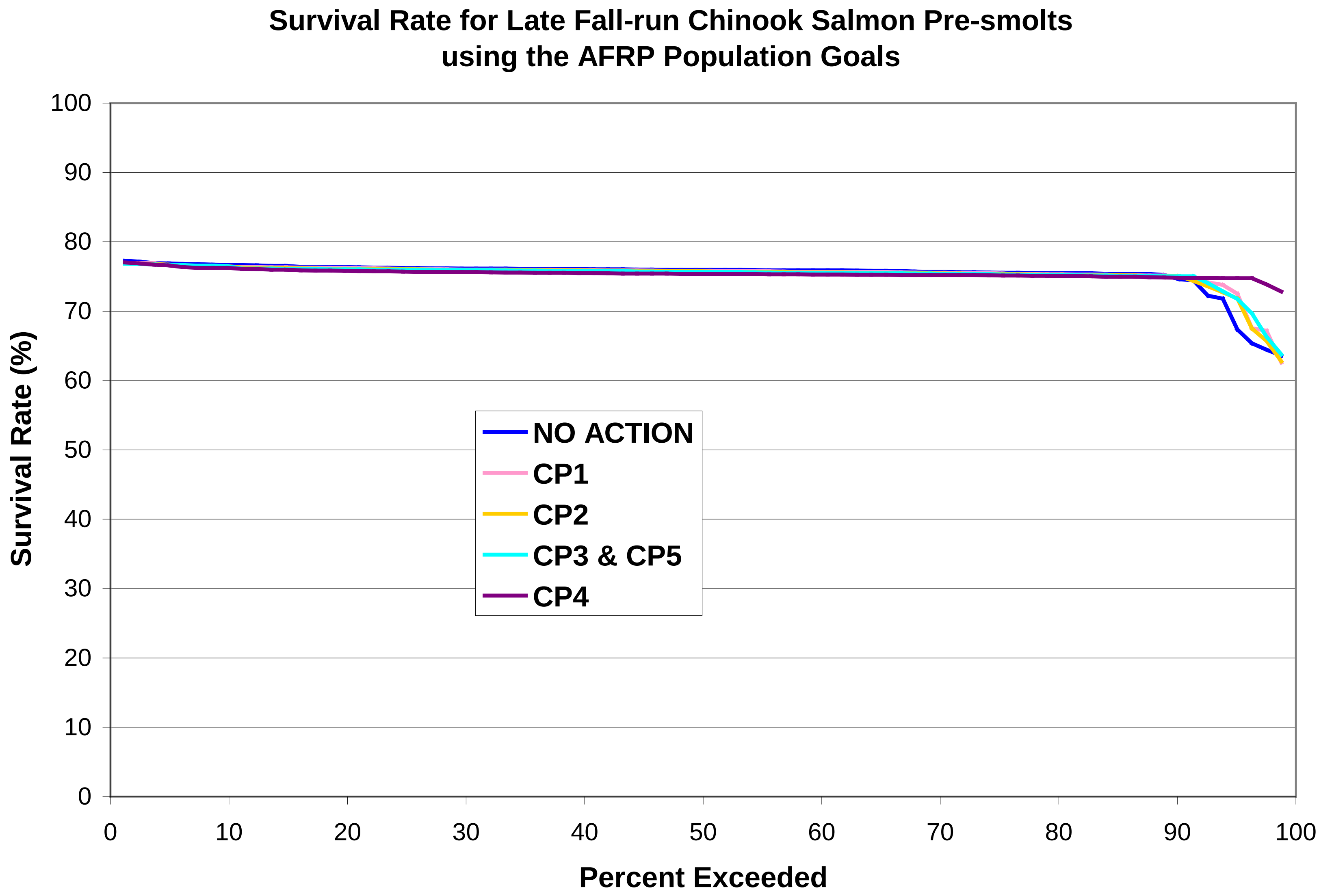

Figure B-59C. Frequency distribution of the survival rate of late fall-run Chinook salmon pre-smolts during the 1921-2003 simulation period based on the AFRP population goals.

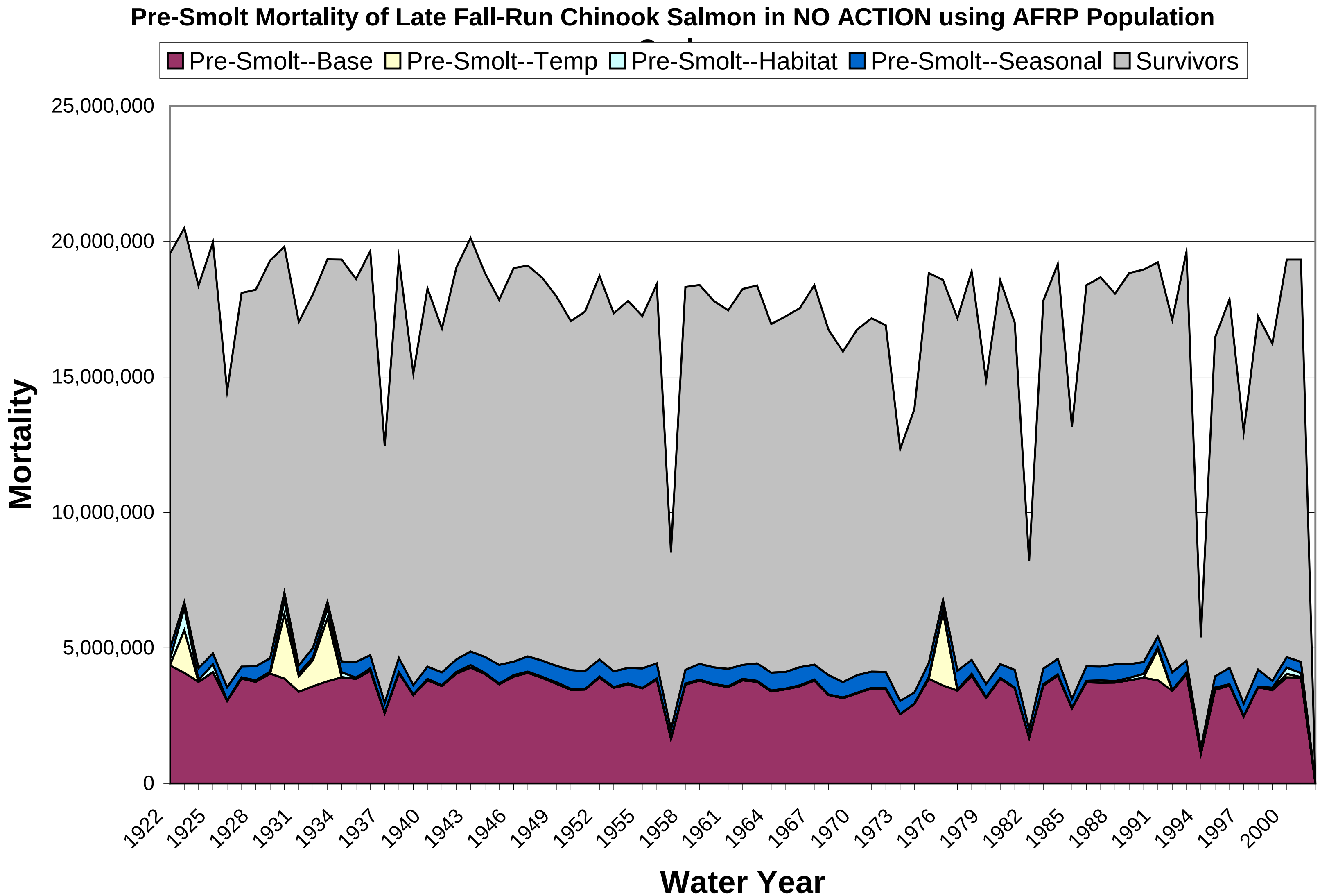

Figure B-60A. Source of mortality of late fall-run Chinook salmon pre-smolts in NO ACTION based on the ARFP population goals.

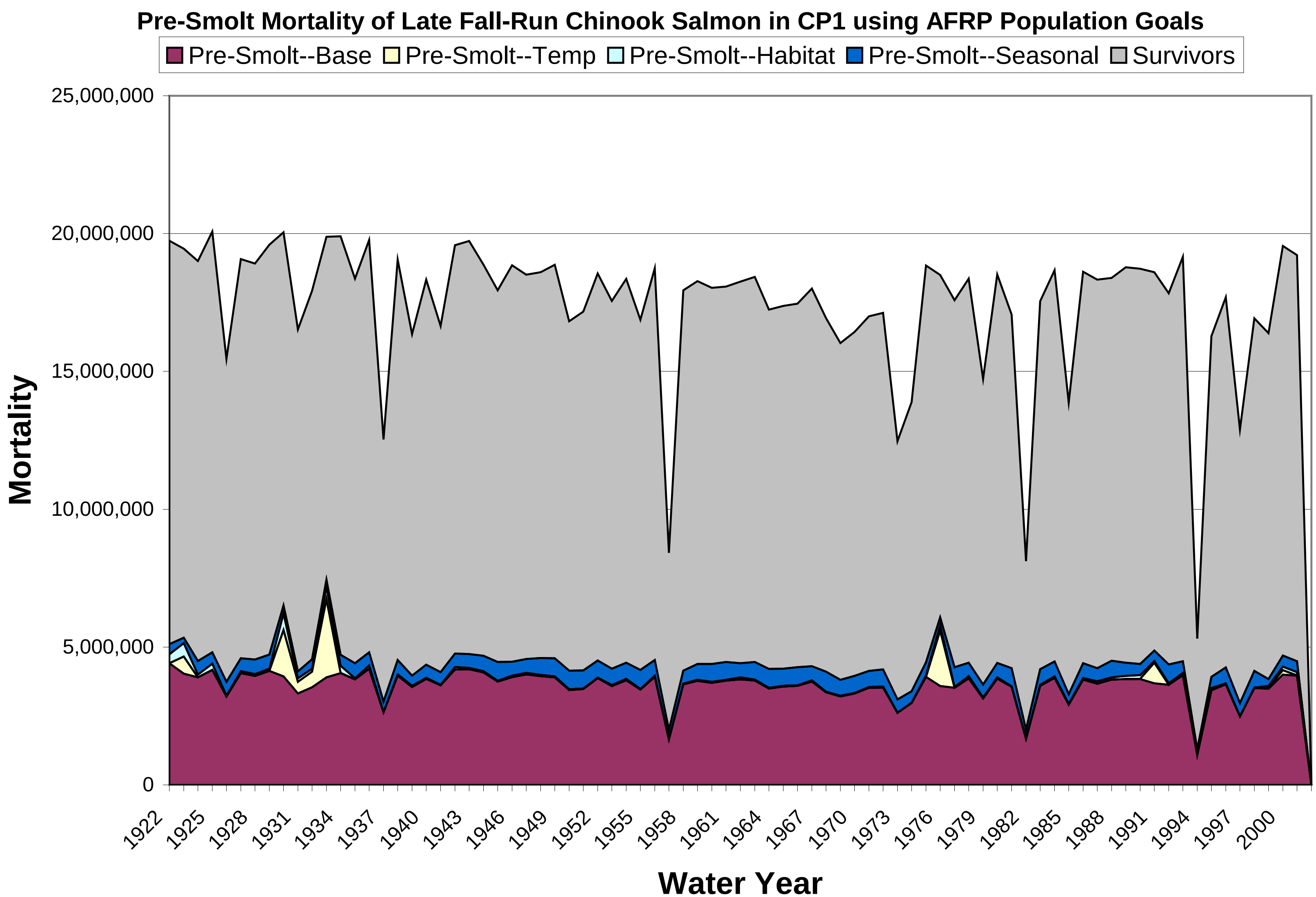

Figure B-60B. Source of mortality of late fall-run Chinook salmon pre-smolts in CP1 based on the ARFP population goals.

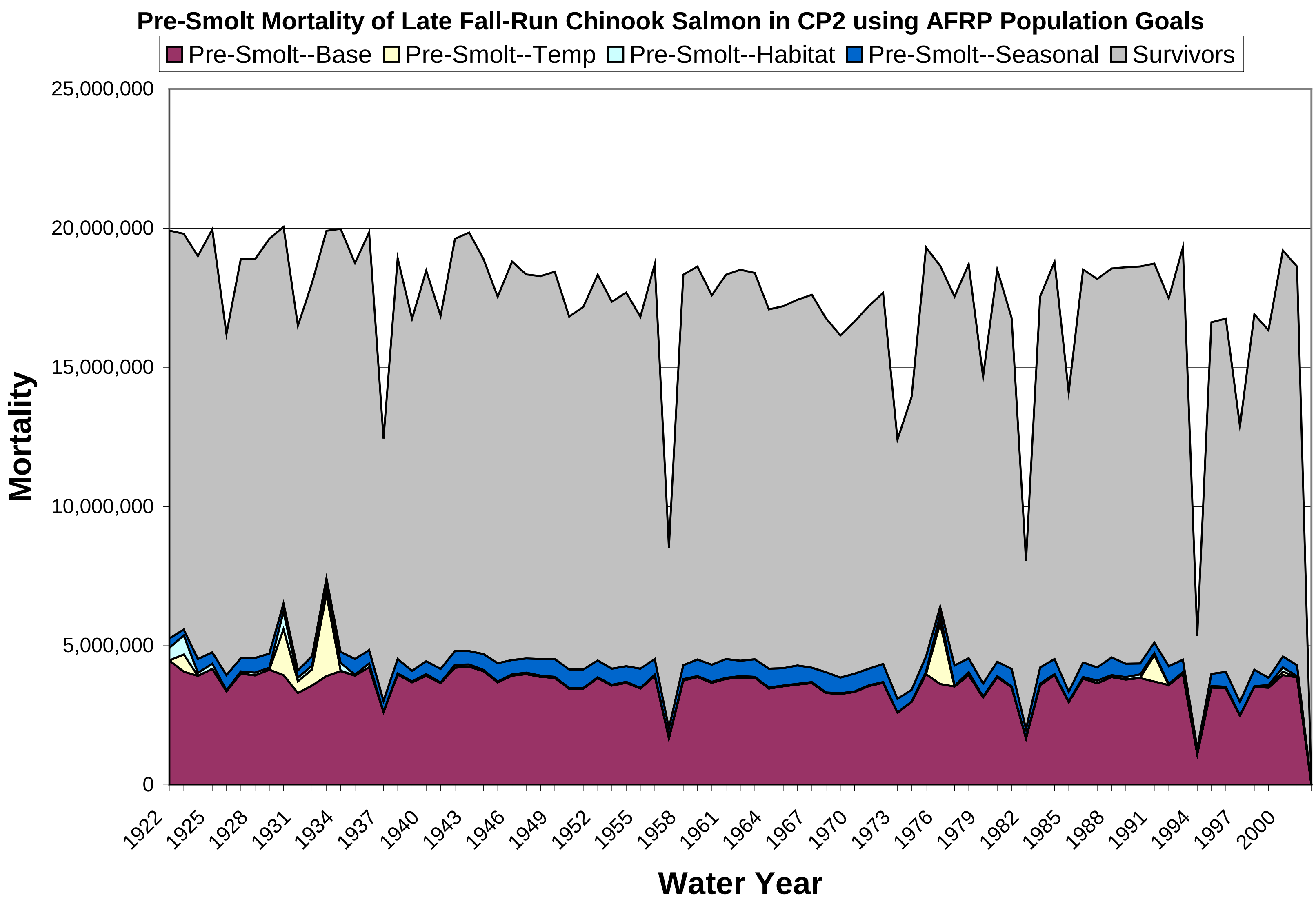

Figure B-60C. Source of mortality of late fall-run Chinook salmon pre-smolts in CP2 based on the ARFP population goals.

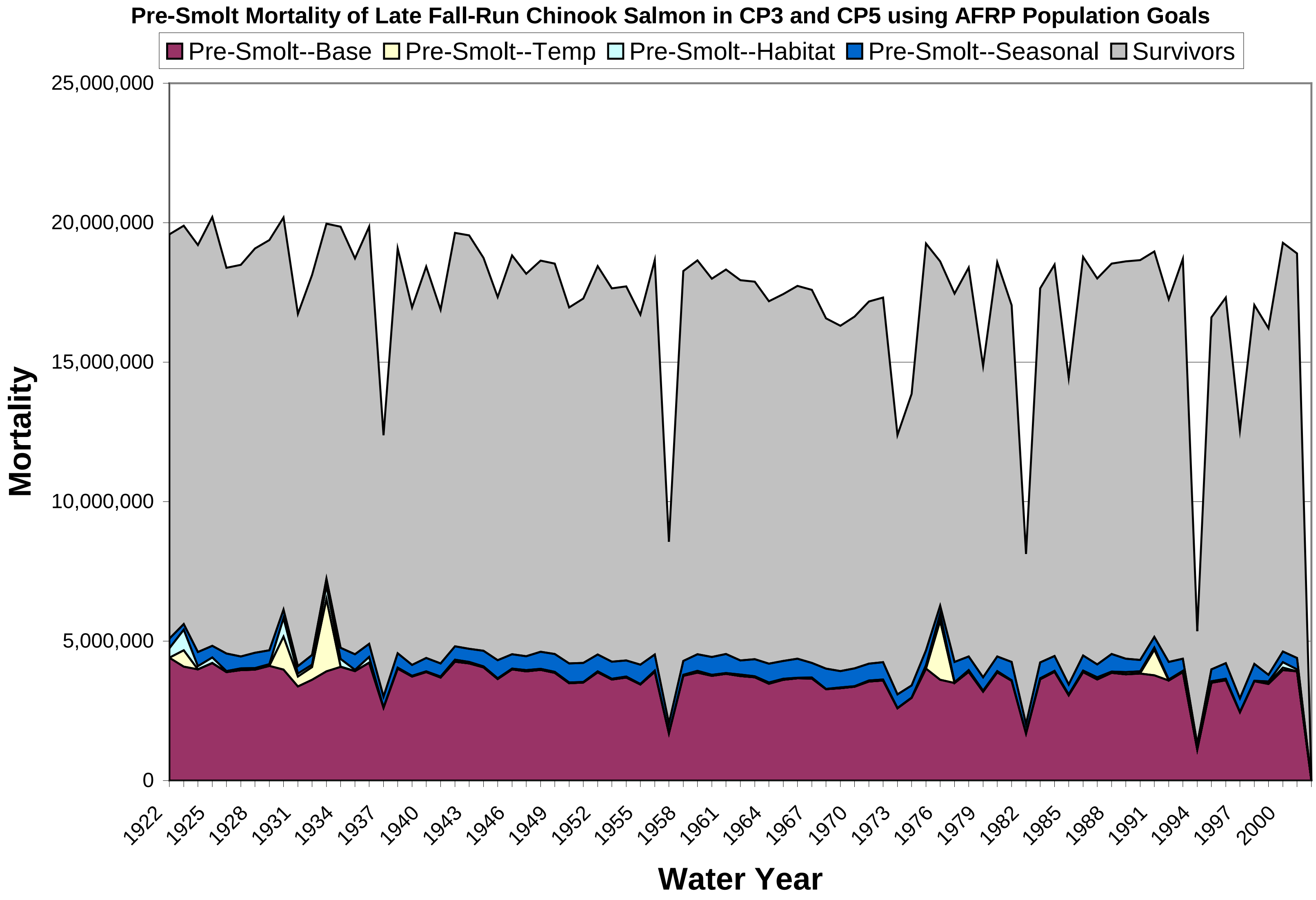

Figure B-60D. Source of mortality of late fall-run Chinook salmon pre-smolts in CP3 and CP5 based on the ARFP population goals.

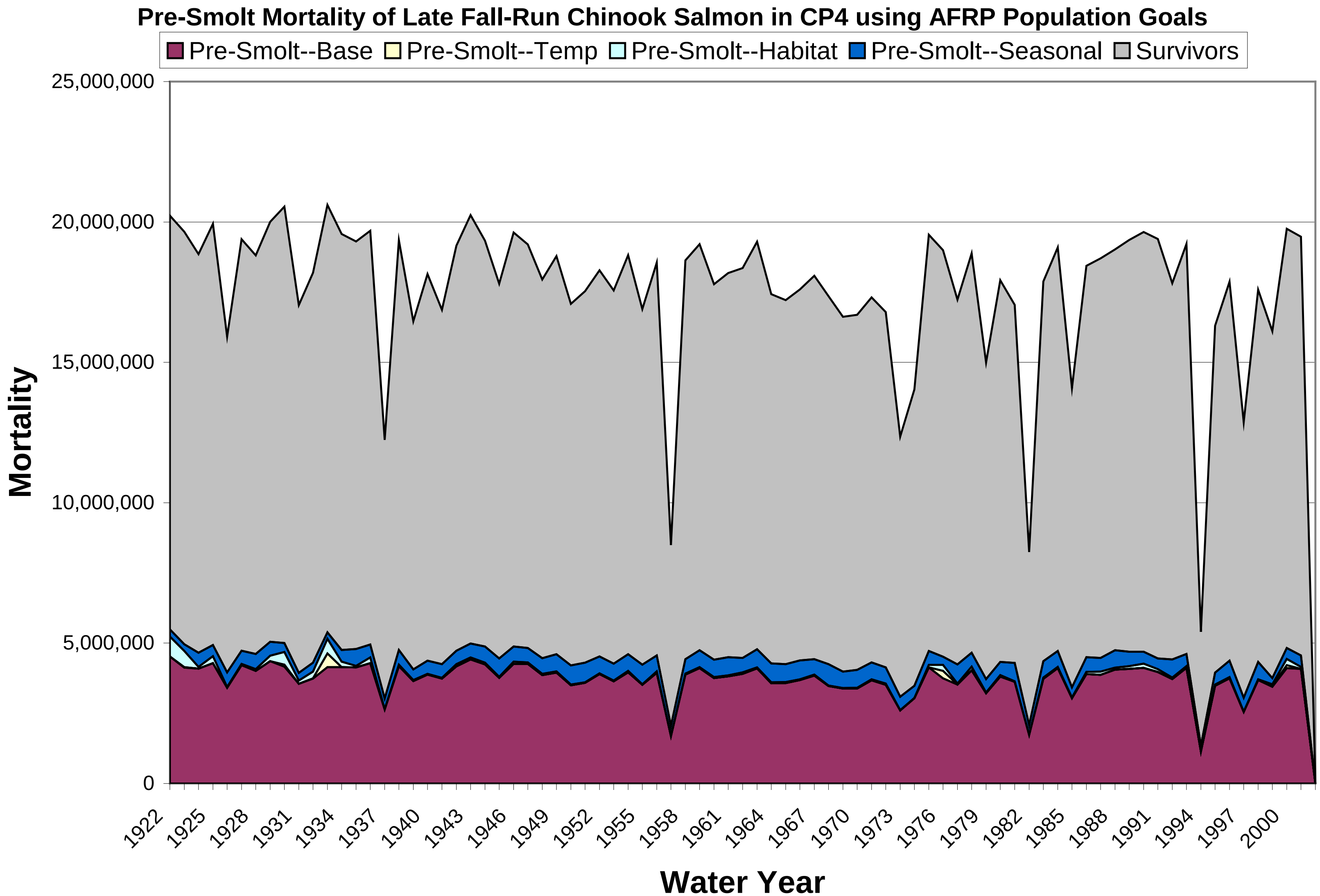

Figure B-60E. Source of mortality of late fall-run Chinook salmon immature smolts in CP4 based on the ARFP population goals.

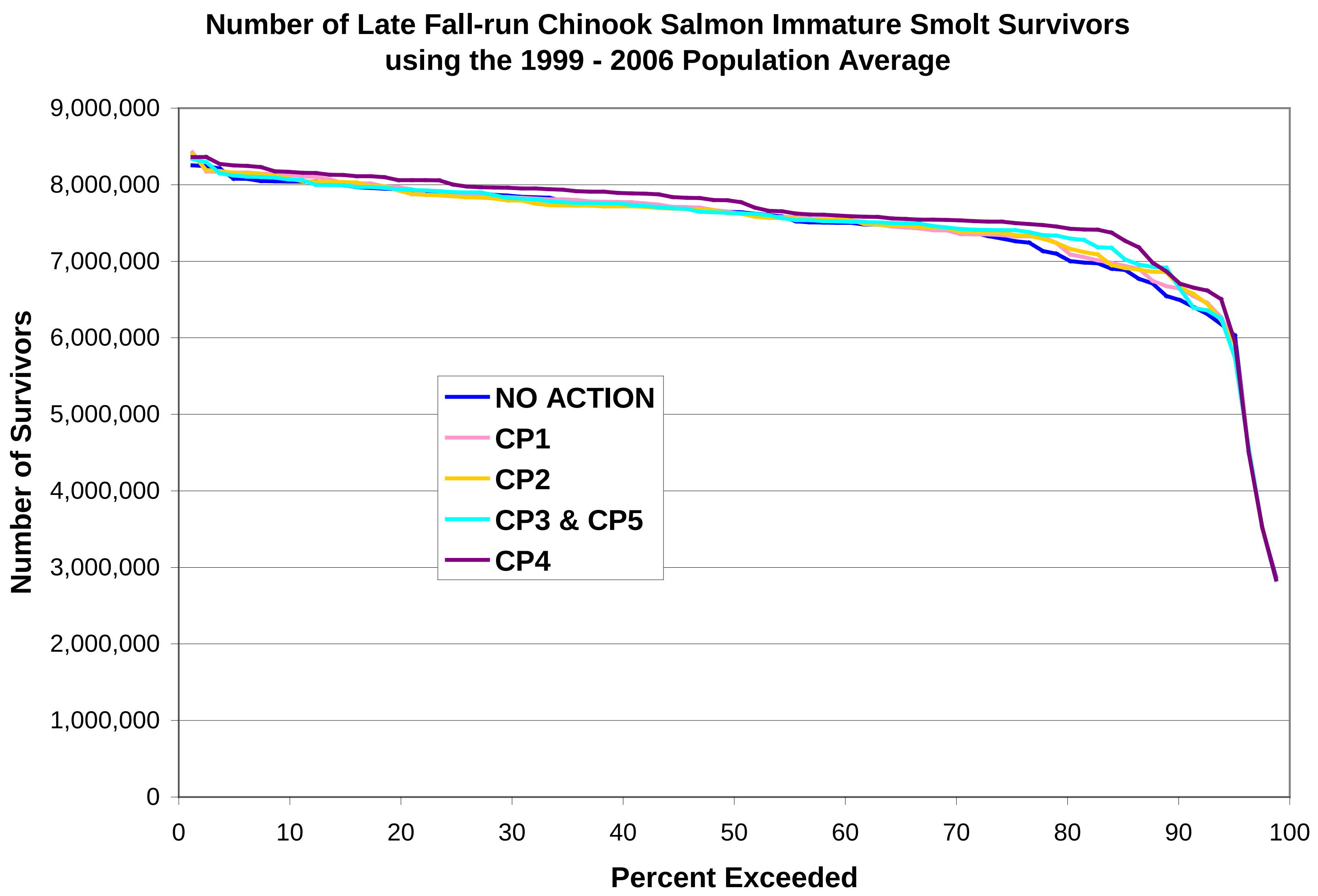

Figure B-61A. Frequency distribution of the number of late fall-run Chinook salmon immature smolt survivors during the 1921-2003 simulation period based on the 1999-2006 population average.

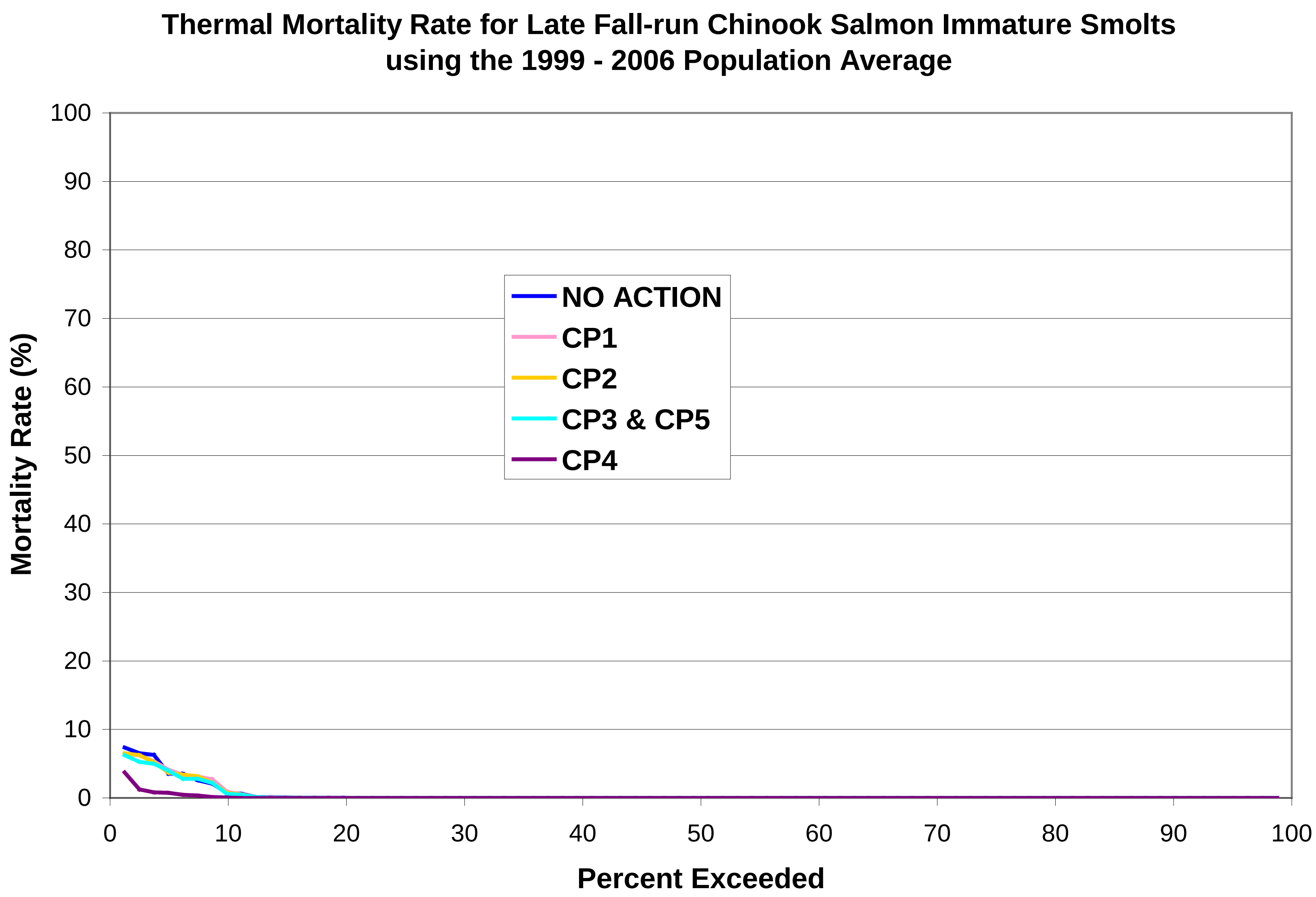

Figure B-61B. Frequency distribution of the thermal mortality rate of late fall-run Chinook salmon immature smolts during the 1921-2003 simulation period based on the 1999-2006 population average.

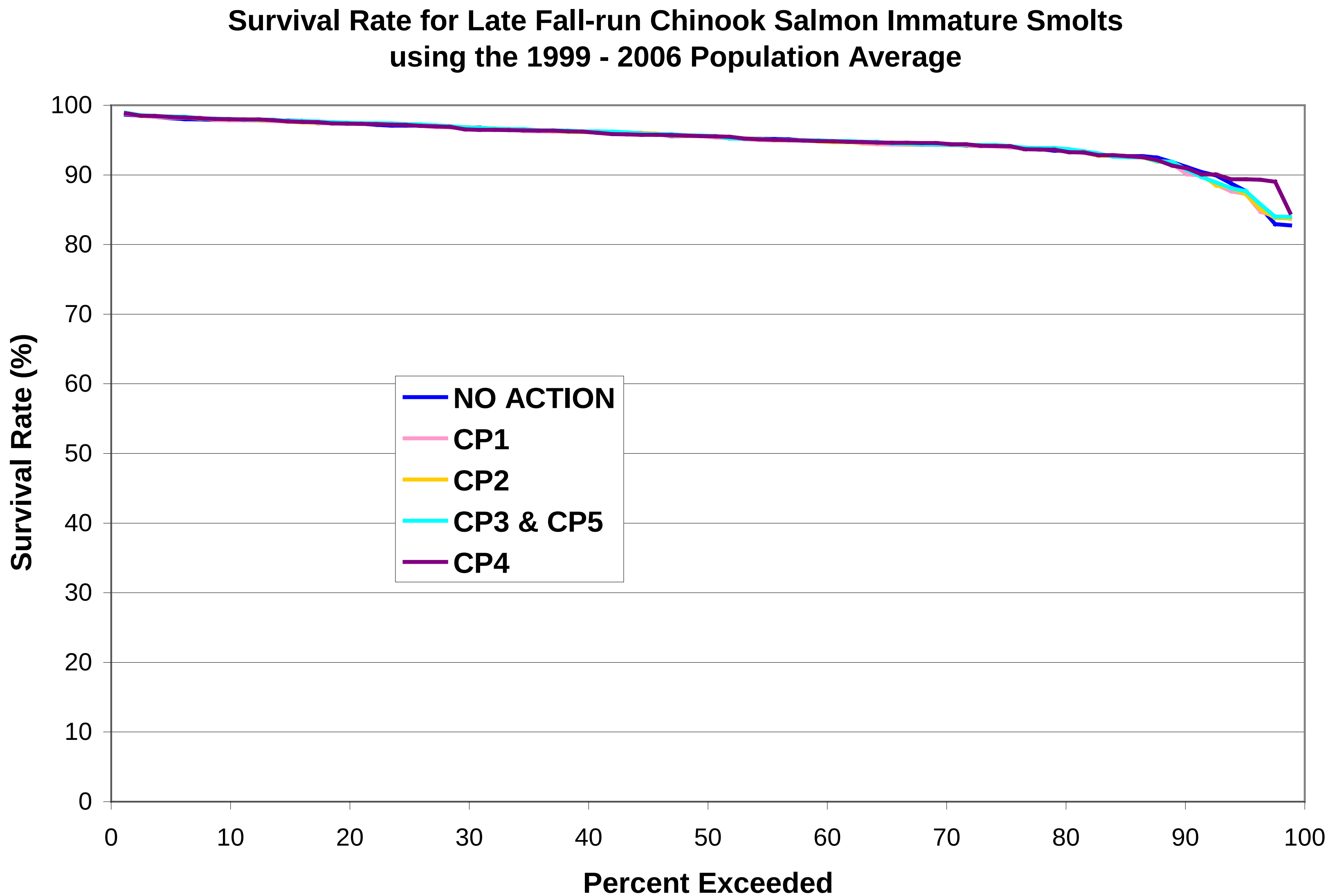

Figure B-61C. Frequency distribution of the survival rate of late fall-run Chinook salmon immature smolts during the 1921-2003 simulation period based on the 1999-2006 population average.

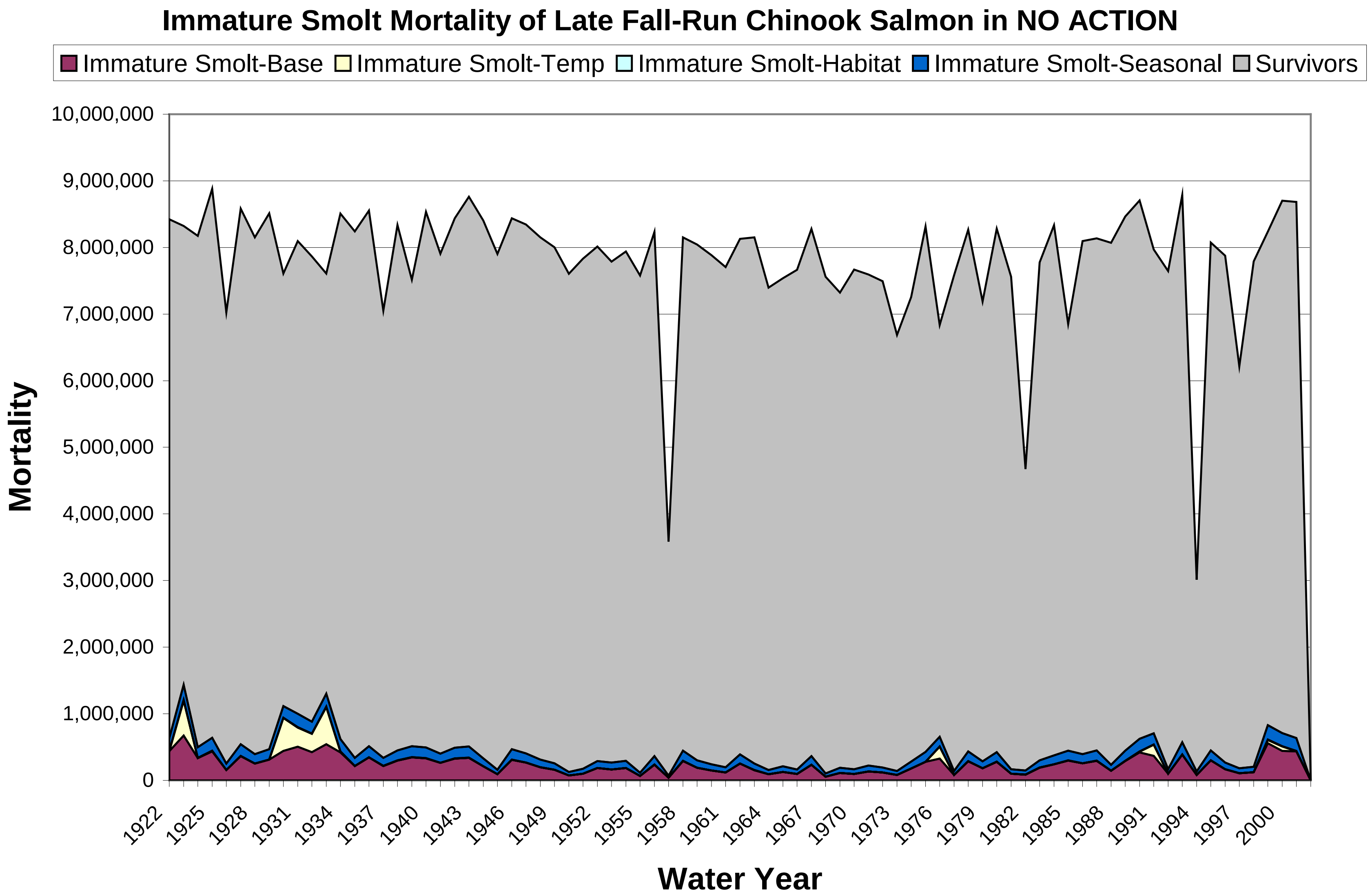

Figure B-62A. Source of mortality of late fall-run Chinook salmon immature smolts in NO ACTION based on the 1999-2006 population average.

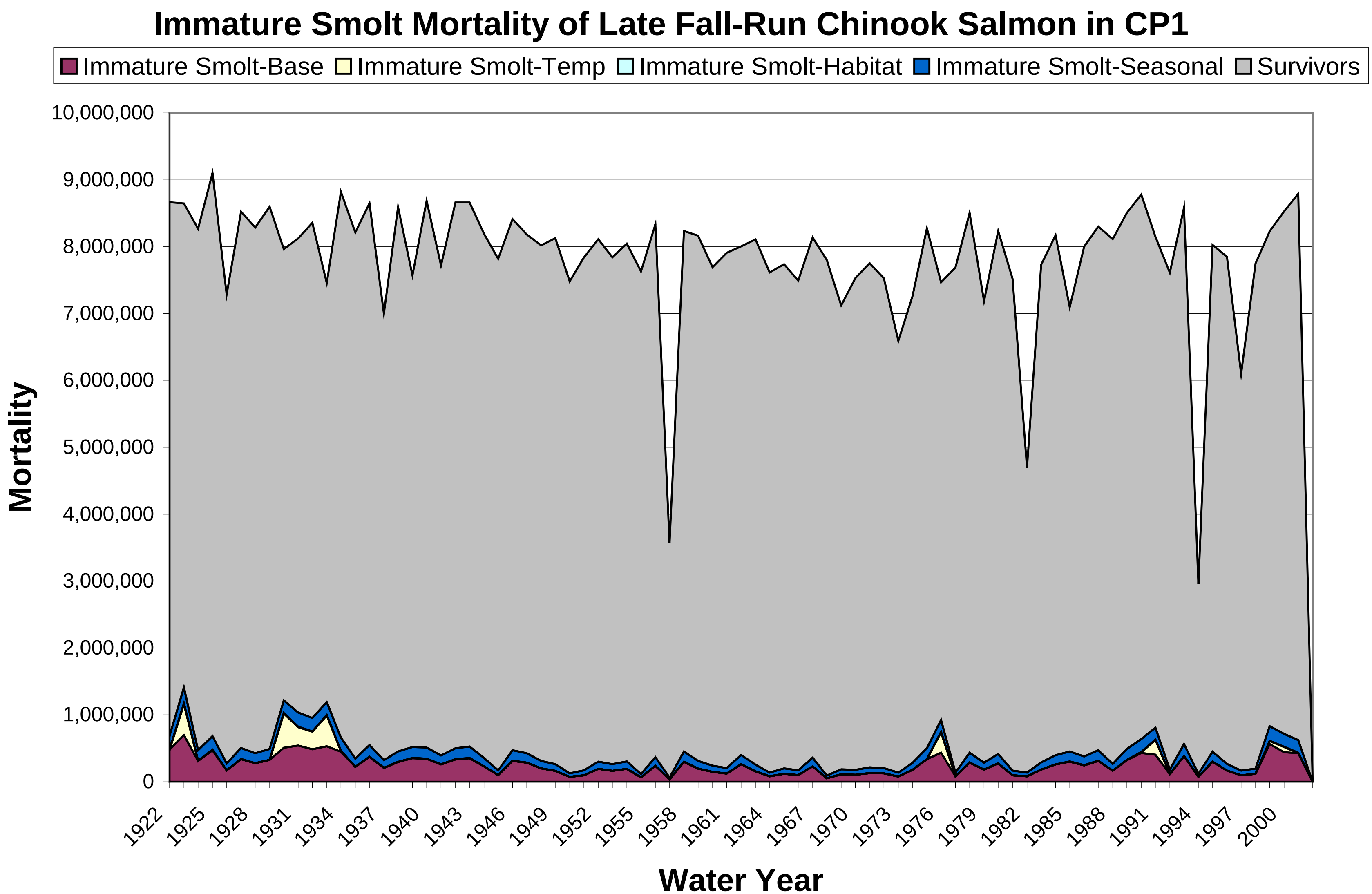

Figure B-62B. Source of mortality of late fall-run Chinook salmon immature smolts in CP1 based on the 1999-2006 population average.

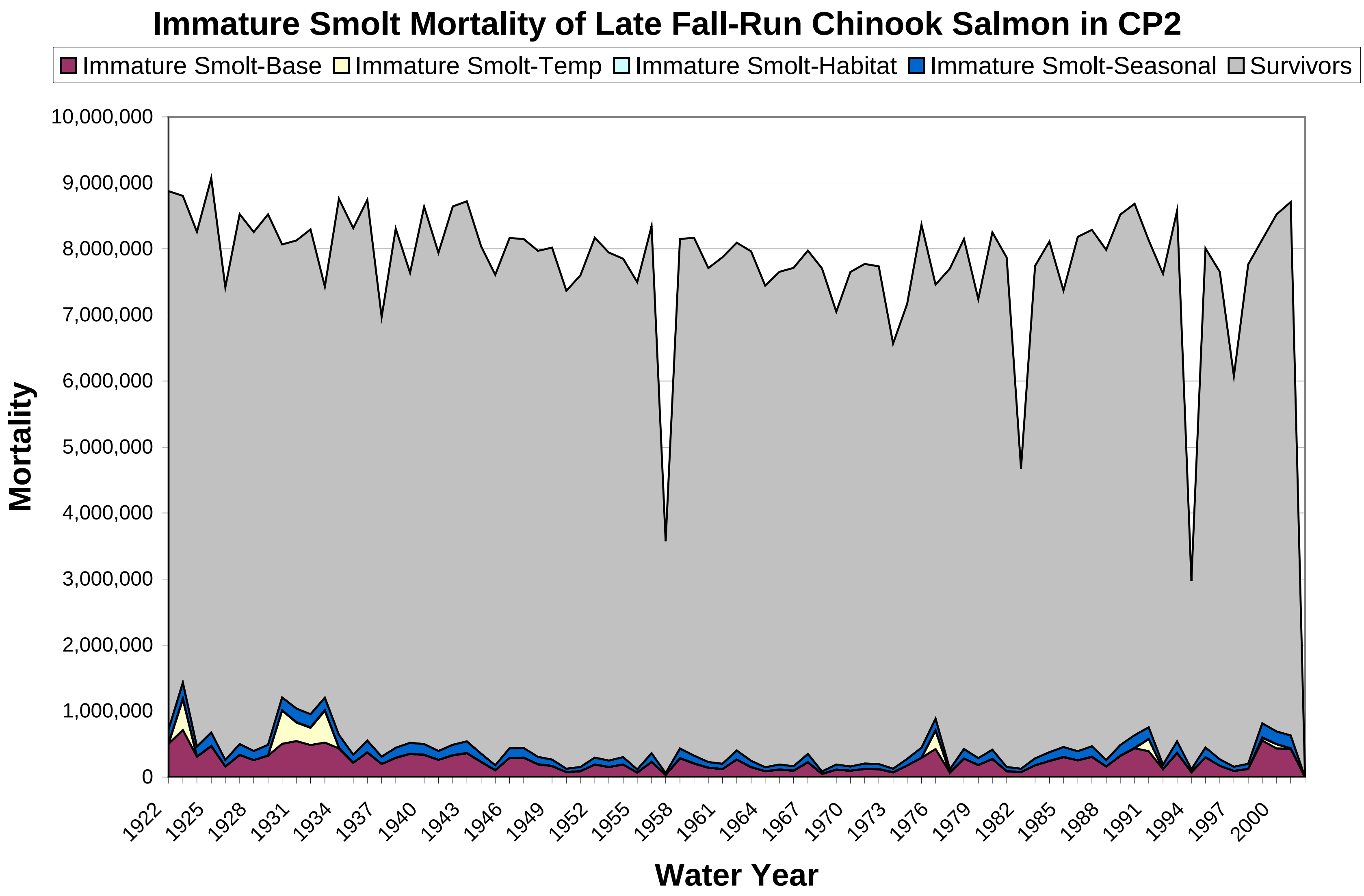

Figure B-62C. Source of mortality of late fall-run Chinook salmon immature smolts in CP2 based on the 1999-2006 population average.

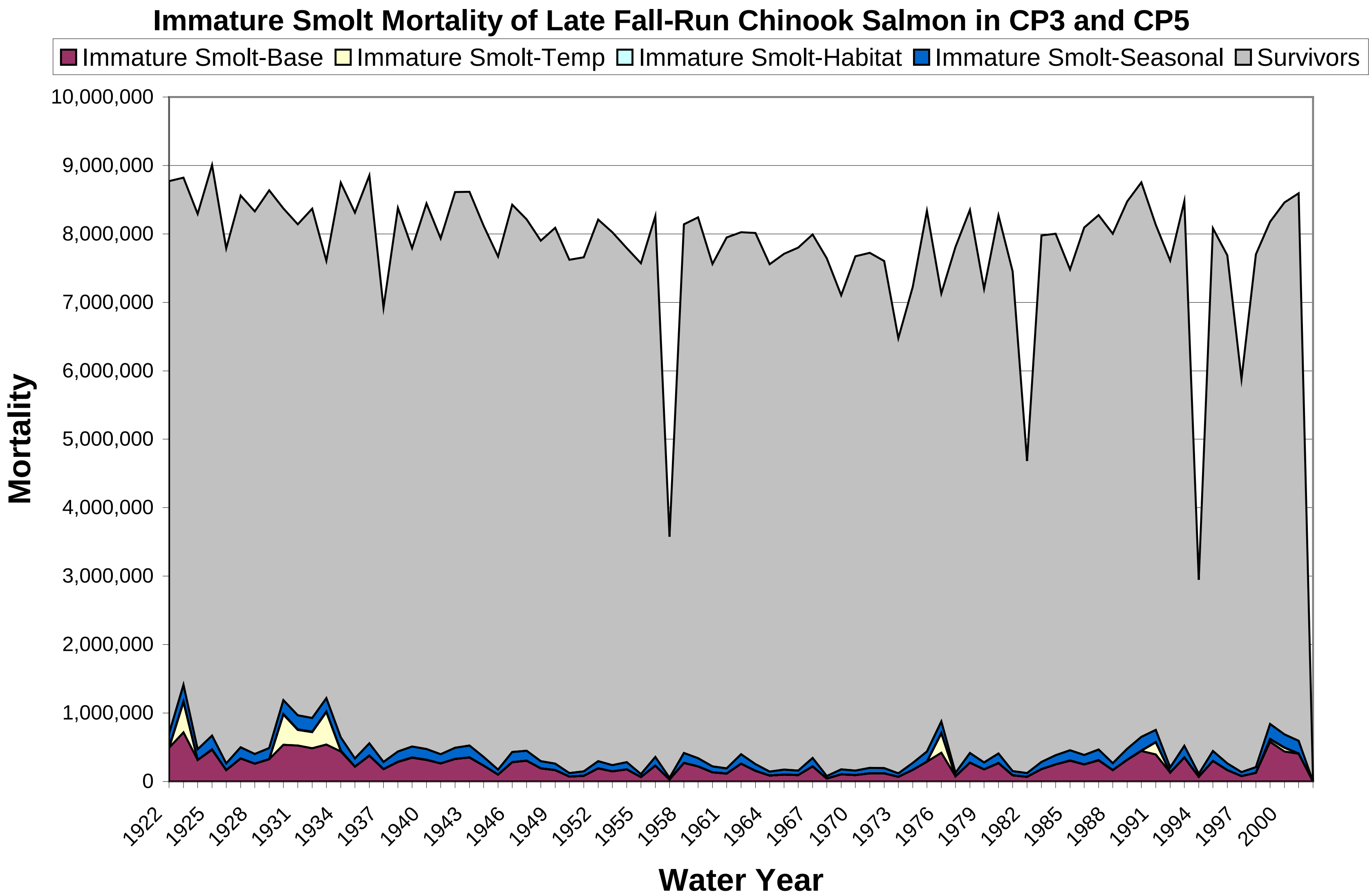

Figure B-62D. Source of mortality of late fall-run Chinook salmon immature smolts in CP3 and CP5 based on the 1999-2006 population average.

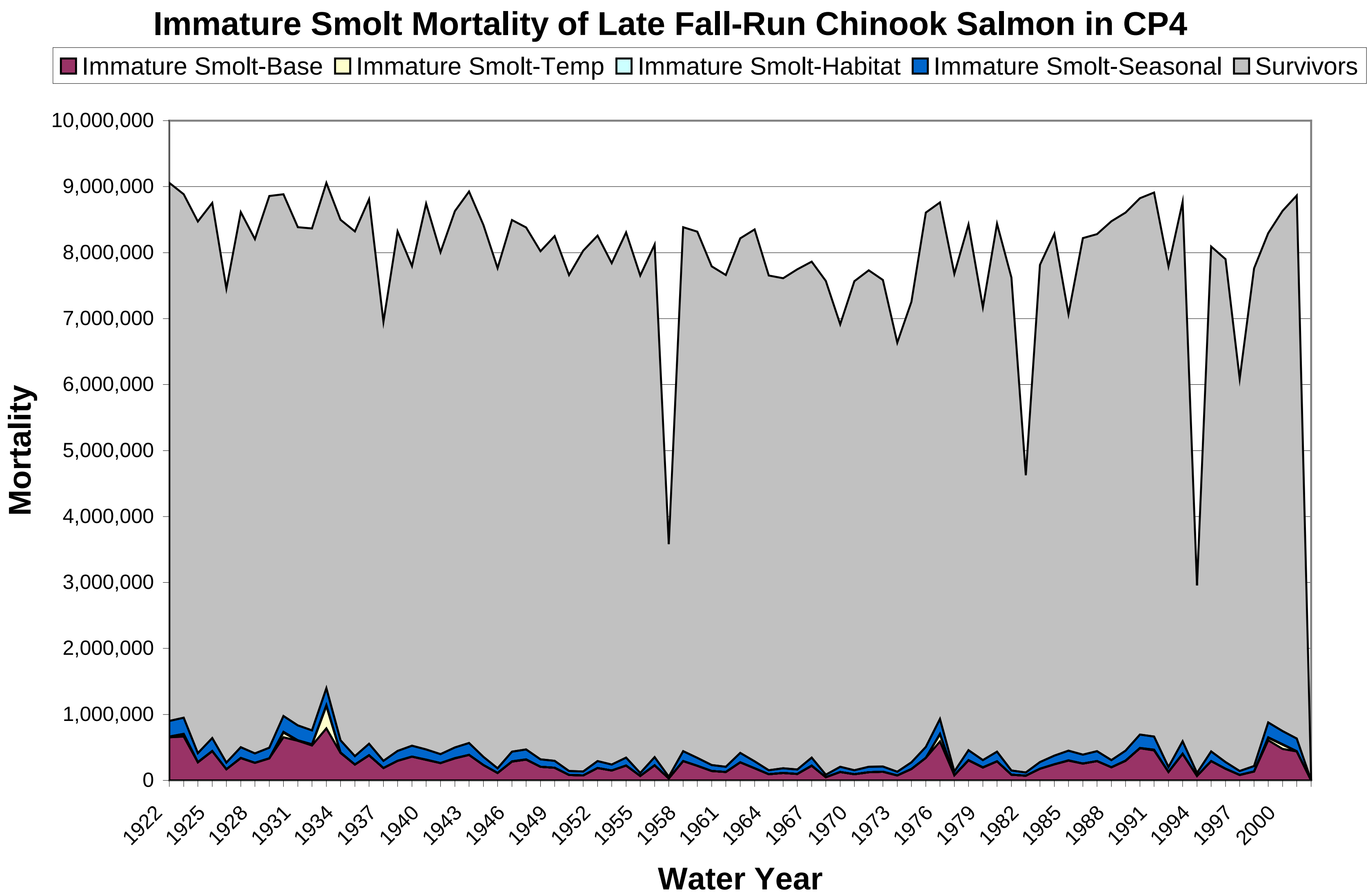

Figure B-62E. Source of mortality of late fall-run Chinook salmon immature smolts in CP4 based on the 1999-2006 population average.

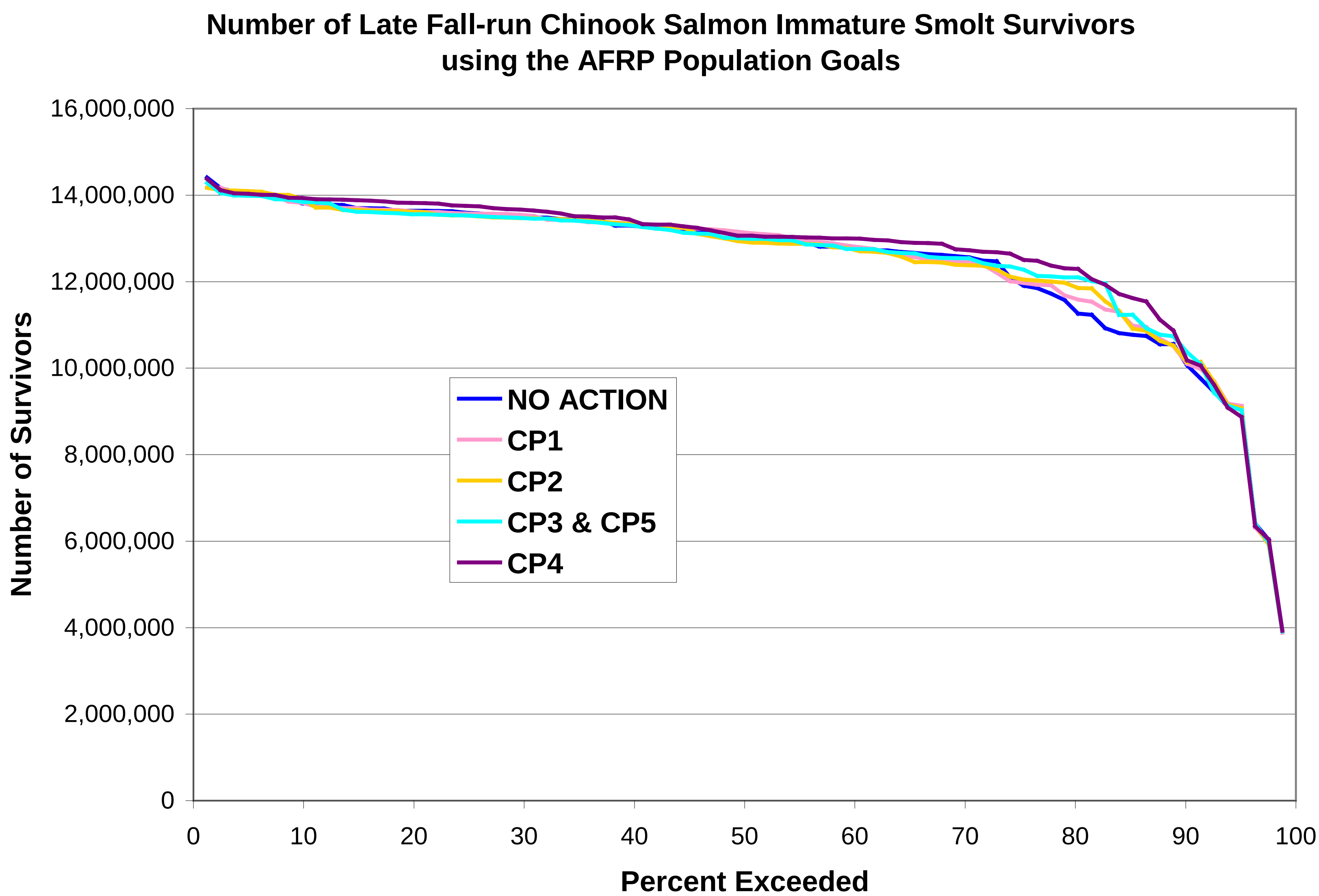

Figure B-63A. Frequency distribution of the number of late fall-run Chinook salmon immature smolt survivors during the 1921-2003 simulation period based on the AFRP population goals.

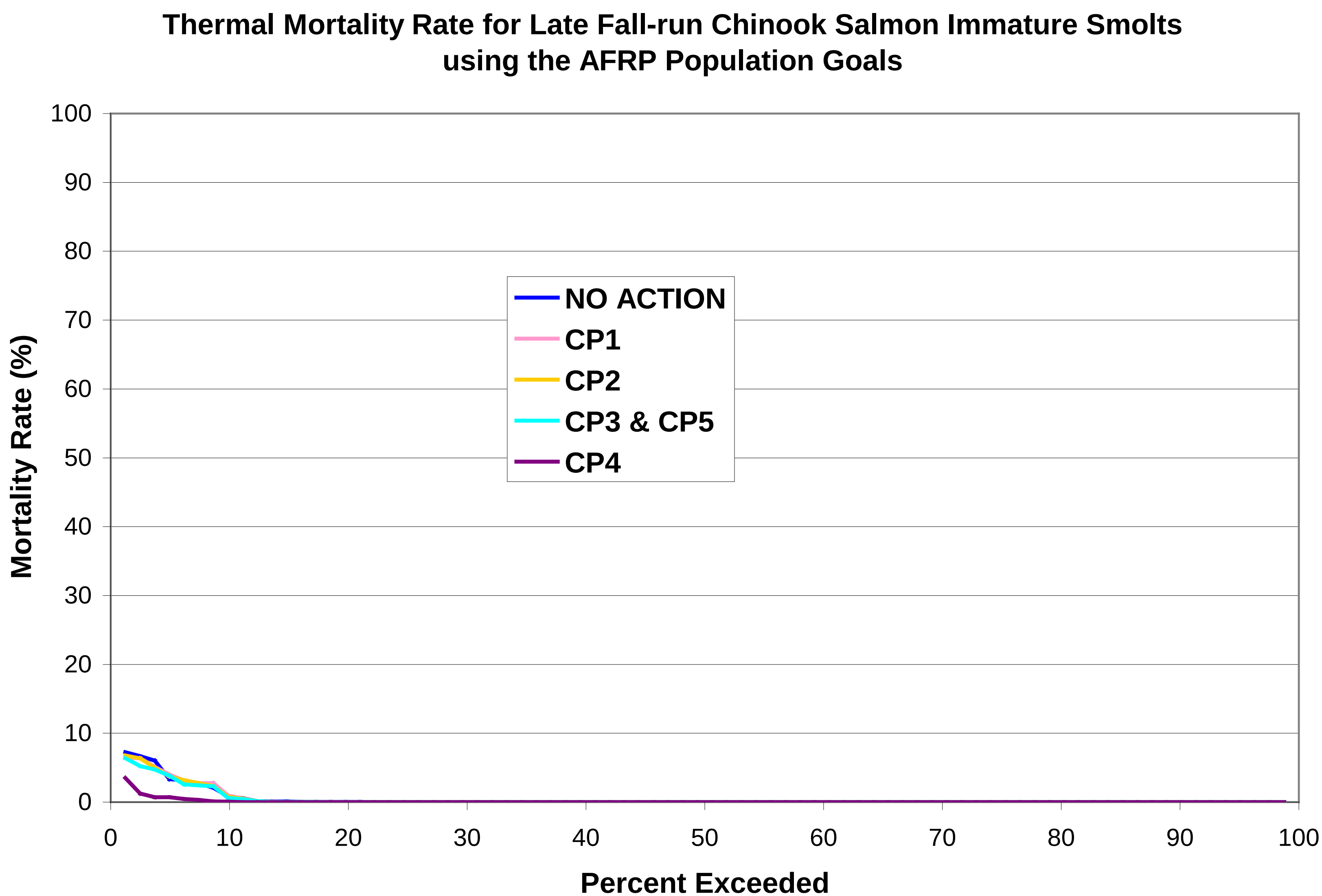

Figure B-63B. Frequency distribution of the thermal mortality rate of late fall-run Chinook salmon immature smolts during the 1921-2003 simulation period based on the AFRP population goals.

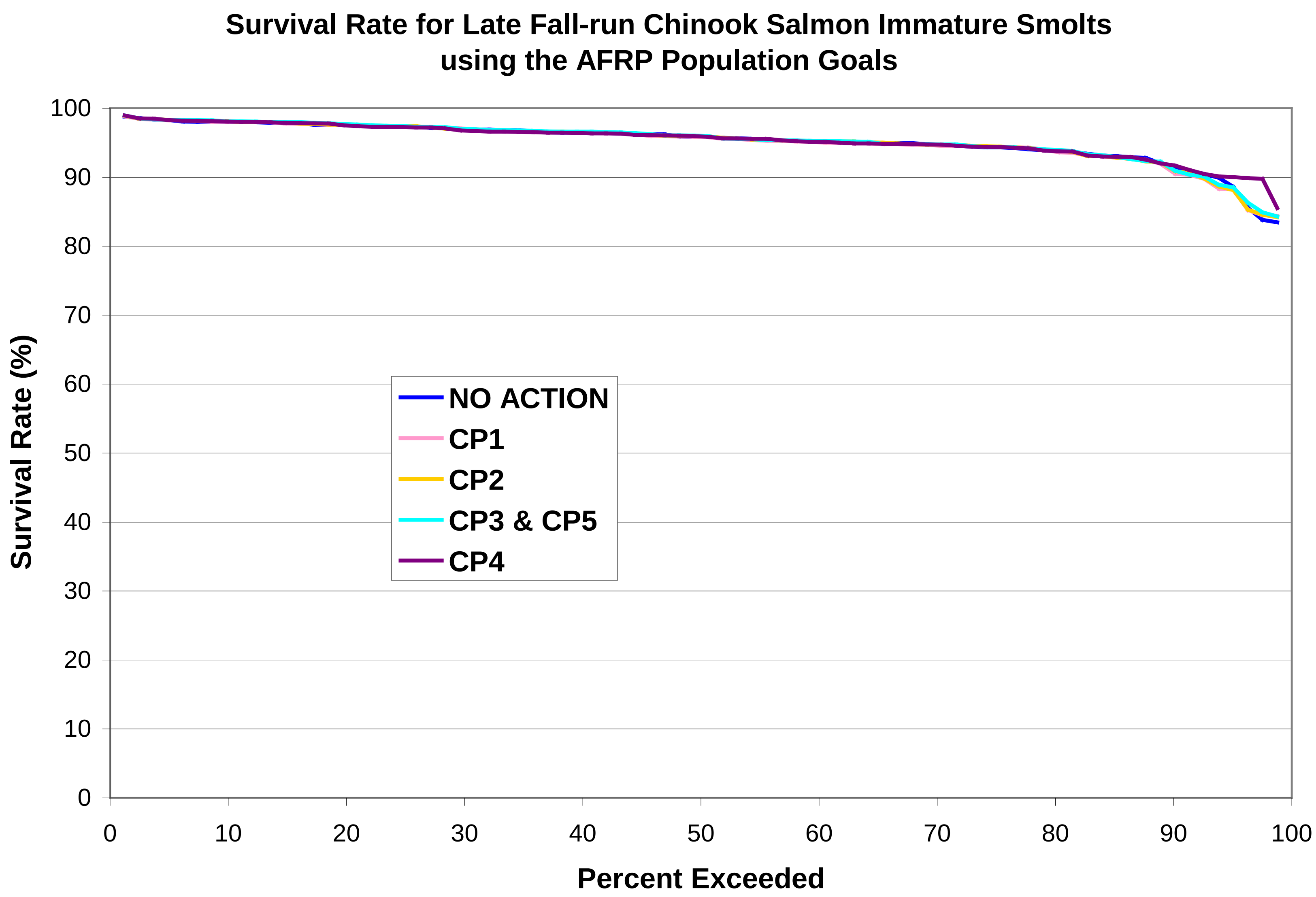

Figure B-63C. Frequency distribution of the survival rate of late fall-run Chinook salmon immature smolts during the 1921-2003 simulation period based on the AFRP population goals.

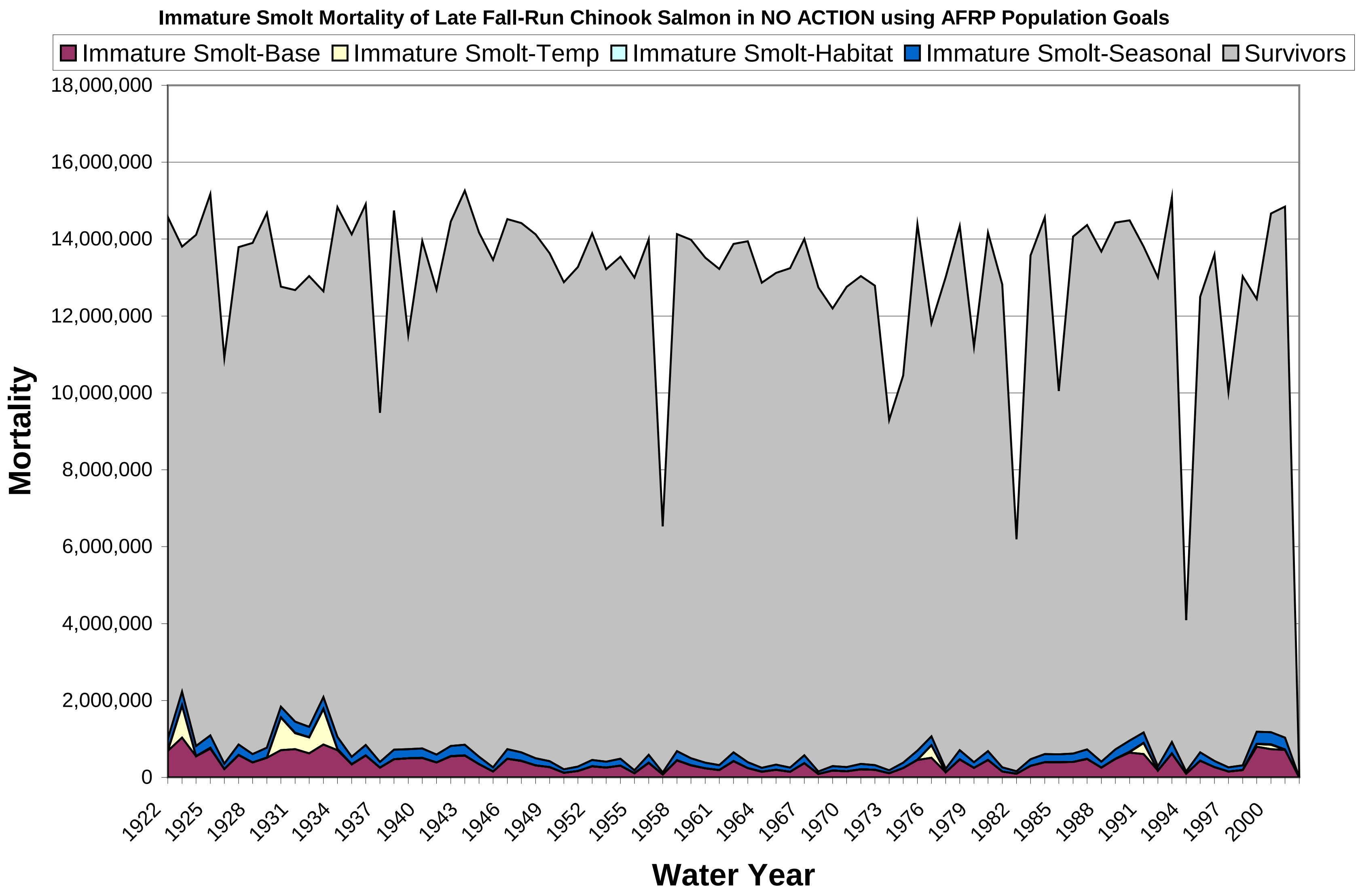

Figure B-64A. Source of mortality of late fall-run Chinook salmon immature smolts in NO ACTION based on the AFRP population goals.

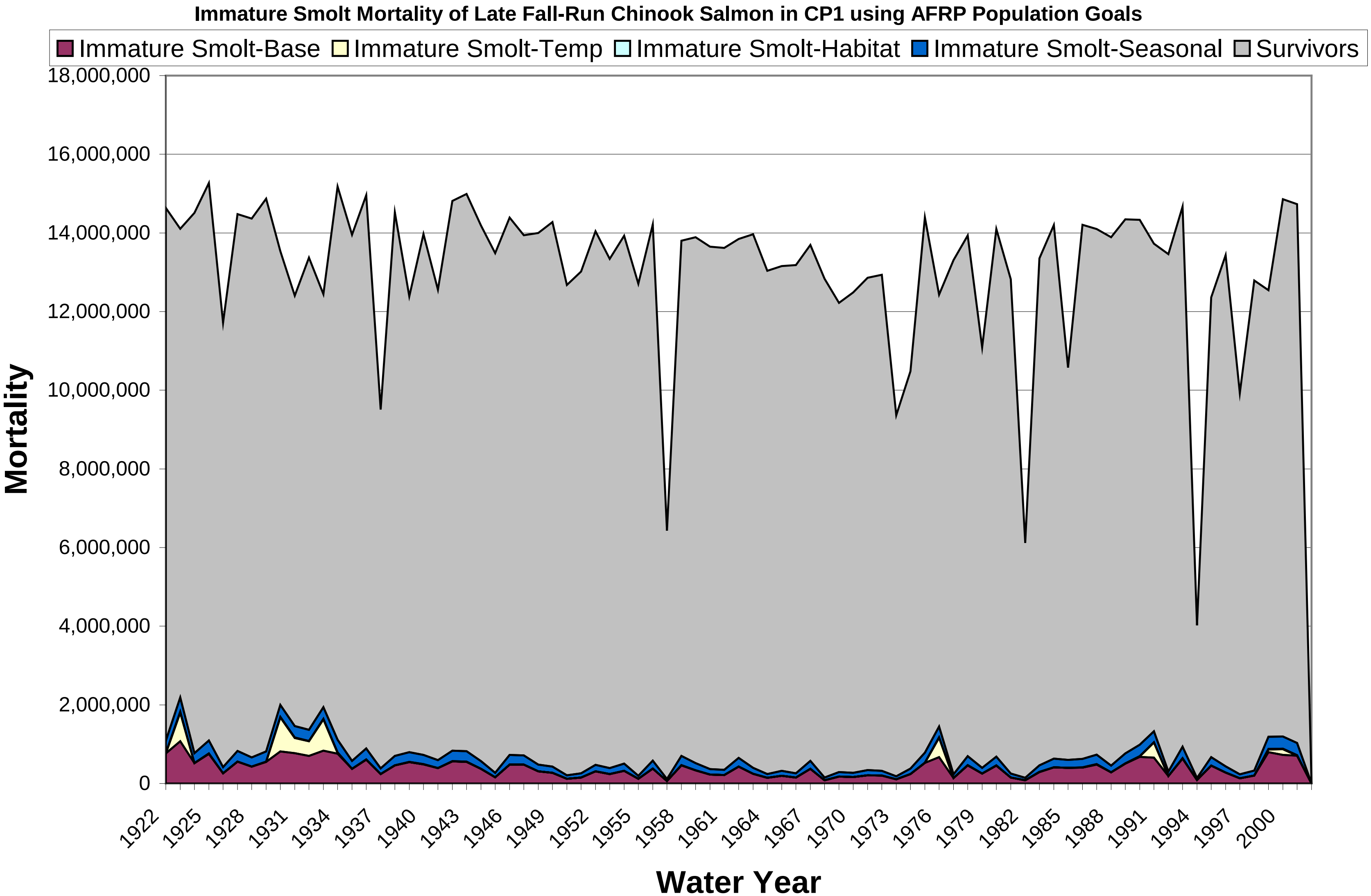

Figure B-64B. Source of mortality of late fall-run Chinook salmon immature smolts in CP1 based on the AFRP population goals.

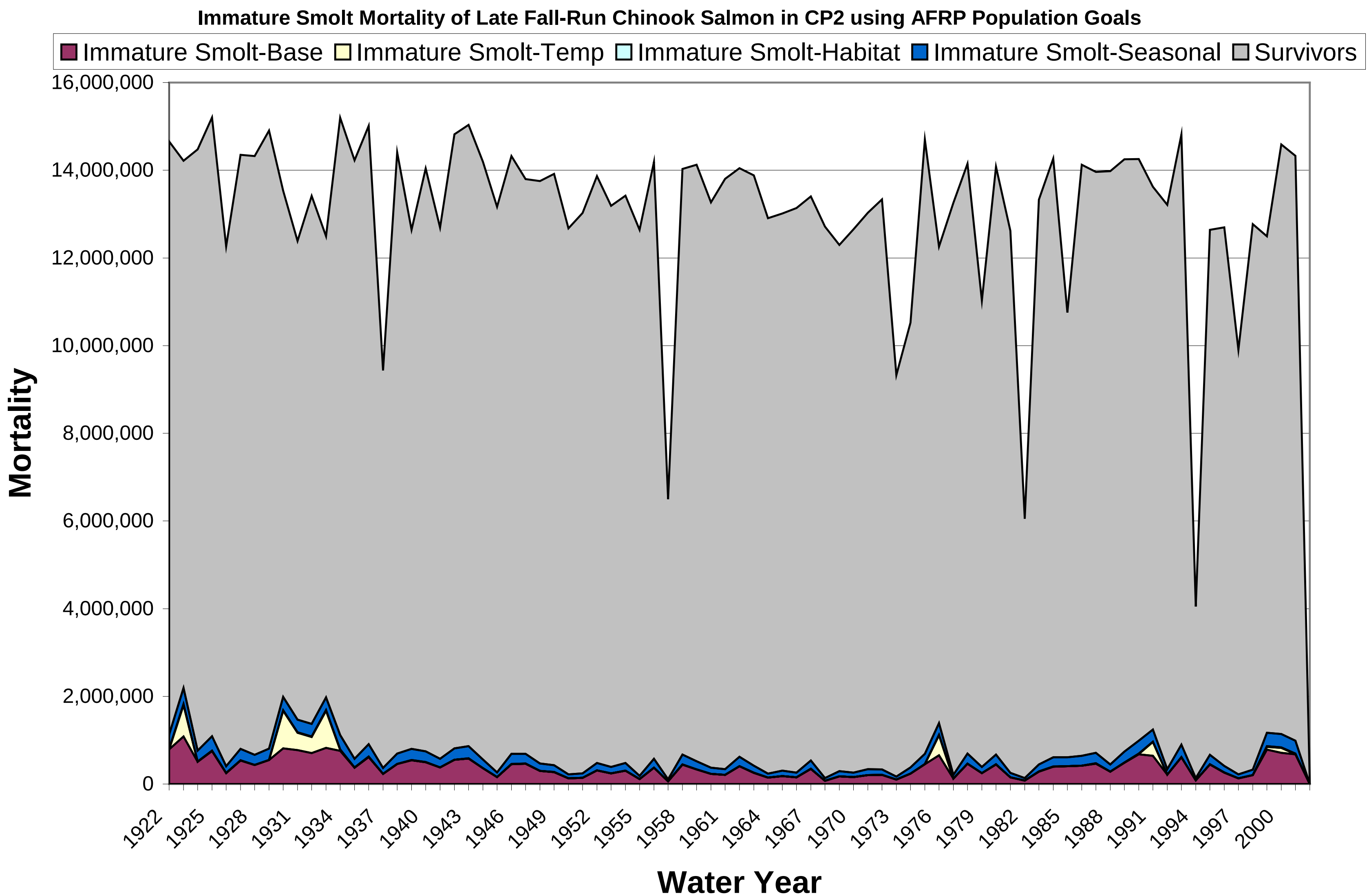

Figure B-64C. Source of mortality of late fall-run Chinook salmon immature smolts in CP2 based on the AFRP population goals.

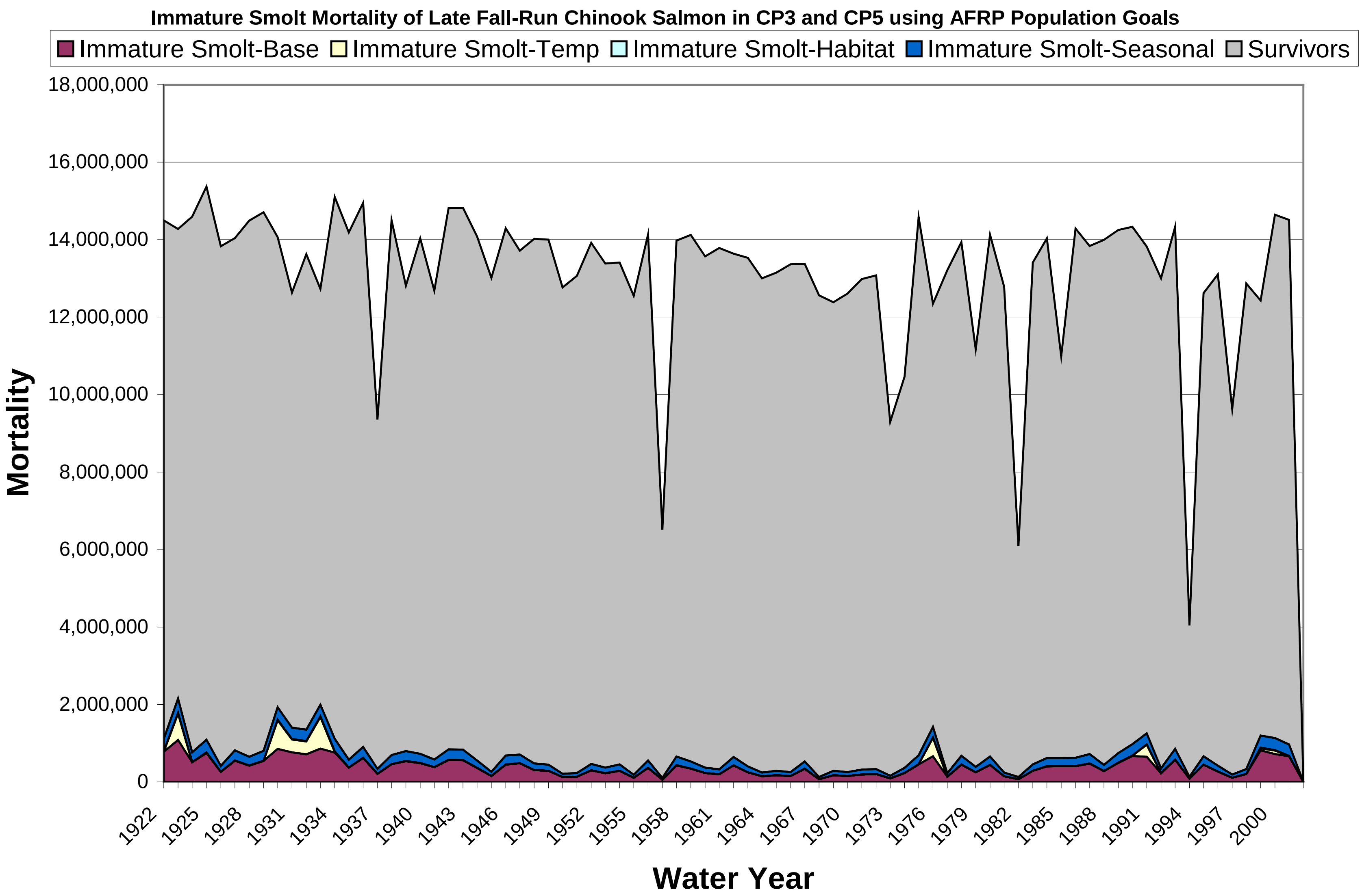

Figure B-64D. Source of mortality of late fall-run Chinook salmon immature smolts in CP3 and CP5 based on the AFRP population goals.

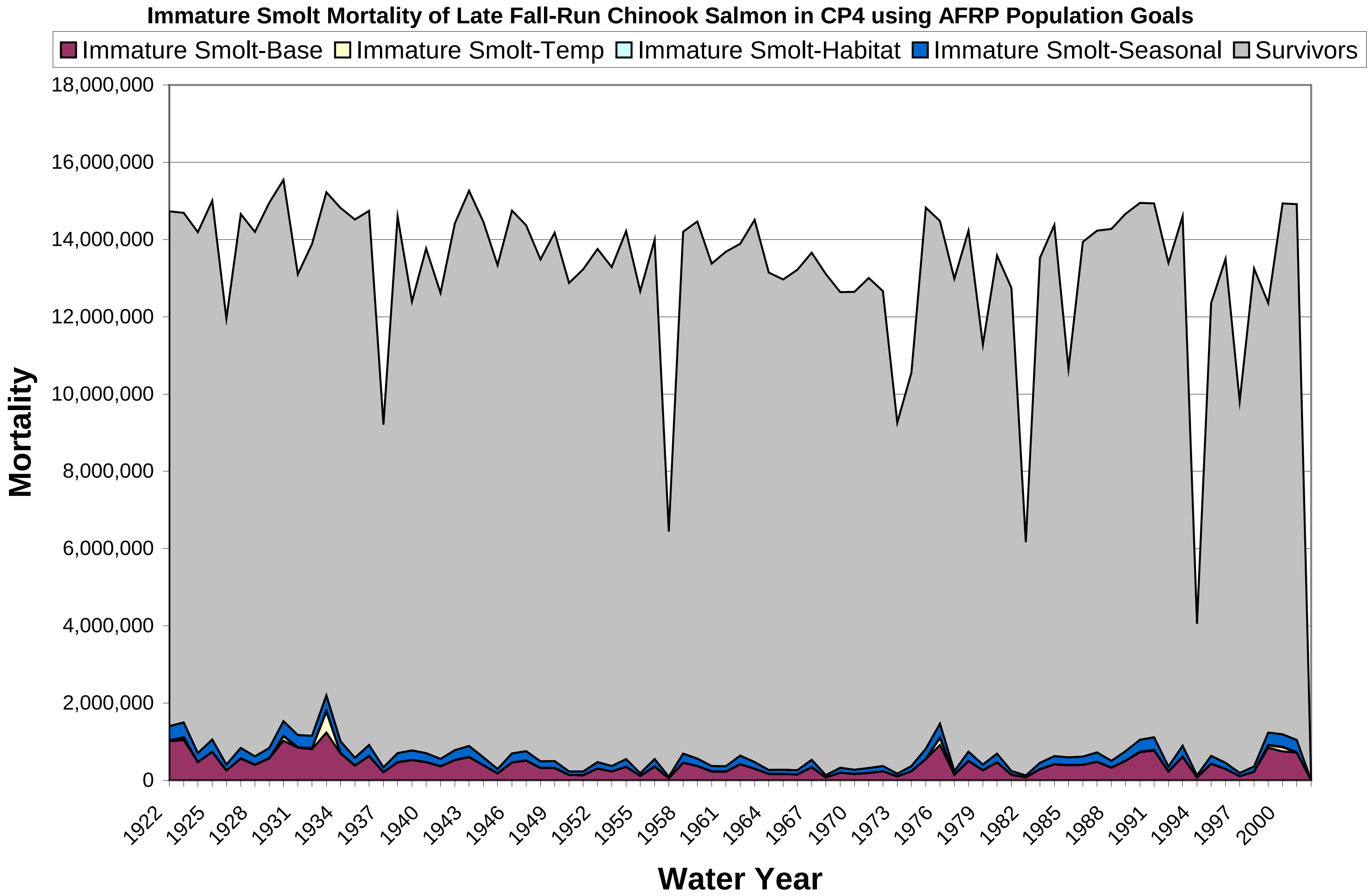

Figure B-64E. Source of mortality of late fall-run Chinook salmon immature smolts in CP4 based on the AFRP population goals.

APPENDIX C

Planning Aid Memorandum

for the Shasta Lake Water Resources Investigation

Sacramento Fish and Wildlife Office

U.S. Fish and Wildlife Service

February 16, 2007

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846

In reply refer to:

Memorandum

To: Regional Director, U.S. Bureau of Reclamation, Sacramento, California

From: Acting Field Supervisor, Sacramento Fish and Wildlife Office, Sacramento, California

Subject: Planning Aid Memorandum on Development of Alternatives for the Shasta Lake Water Resources Investigation

The Fish and Wildlife Service (Service) has coordinated with the Bureau of Reclamation (Reclamation) in early project planning for the Shasta Lake Water Resources Investigation (SLWRI) since October 2001. This interagency coordination has been facilitated, and guided by, the Fish and Wildlife Coordination Act (FWCA) (48 stat. 401, as amended: 16 U.S.C. 661 et seq.). The FWCA requires Federal agencies proposing water resource development projects or involved in issuance of related permits or licenses to consult with the Service and provide equal consideration to the conservation, rehabilitation, and enhancement of fish and wildlife resources with other project purposes. To date, the SLWRI planning process has included the identification of: (1) pertinent water and related resource problems, needs, and opportunities;

(2) planning objectives; and (3) principles, constraints, and criteria under which plan formulation should proceed. More recent planning activities have included exploration and derivation of initial alternatives to meet defined project objectives.

The Service provided an administrative draft Planning Aid Memorandum (PAM) to Reclamation in December 2005. This document finalizes that PAM and is intended to: (1) summarize the Service's views and positions on planning and implementation efforts provided for in related water resources legislation and programs such as the Central Valley Project Improvement Act (CVPIA) and CALFED Bay-Delta Program (CALFED); (2) identify potential beneficial and adverse effects to fish and wildlife resources for future evaluation; and (3) provide recommendations to the SLWRI planning process so as to maximize project benefits for fish and wildlife, while—congruent with the Service's Mitigation Policy (Federal Register 46(15):7644-7663)—avoiding, minimizing, and compensating for adverse effects to fish and wildlife resources.

This PAM focuses on the SLWRI planning process, pertinent environmental analyses and protections, and allocation of project benefits should Shasta Lake be enlarged. However, it should be noted some of the recommendations and concepts provided herein could broadly apply to other proposed surface water supply projects (e.g., Sites Reservoir, Los Vaqueros Reservoir expansion, Delta Islands, and upper San Joaquin River storage).

BACKGROUND

Project Description

Beginning in the late 1990s, Reclamation began assessing options for increasing water storage at Shasta Lake by raising Shasta Dam (USBR 1999). In 2000, the CALFED final Programmatic Record of Decision (ROD) (CALFED, 2000a) identified an enlarged Shasta Lake as a means to increase the cold water pool available to maintain certain fisheries in the upper Sacramento River and to provide a more reliable water supply. That same year, Reclamation reinitiated a feasibility-level investigation to evaluate the potential for enlarging Shasta Dam—the SLWRI (USBR 2004a; 2004b).

In 2004, the following overall mission statement was defined for the SLWRI:

> *Mission Statement*: To develop an implementable plan primarily involving the enlargement of Shasta Dam and Lake to promote increased survival of anadromous fish populations in the upper Sacramento River; increased water supply reliability; and to the extent possible through meeting these objectives, include features to benefit other identified ecosystem, flood control, and water resources needs (USBR 2004a).

The SLWRI Environmental Scoping Report (USBR 2006a) lists two primary objectives for the SLWRI: (1) to increase the restoration of anadromous fish populations in the Sacramento River—primarily upstream from the Red Bluff Diversion Dam, and (2) to increase water supplies and water supply reliability for agricultural, municipal, industrial and environmental purposes to help meet future water demands (with a focus on enlarging Shasta Dam and Lake). To the extent possible, the following secondary objectives would be met: (1) preserve and restore ecosystem resources in the Shasta Lake area and along the upper Sacramento River; (2) reduce flood damages along the Sacramento River; (3) develop additional hydropower capabilities at Shasta Dam; and (4) preserve outdoor recreation opportunities at Shasta Lake.

SLWRI planning principles have been framed such that "[P]rimary consideration should be given to recommendations in the CALFED ROD," and "[A]lternatives should be formulated to neither preclude nor enhance development and implementation of other elements of the CALFED program or other water resources programs and projects in the Central Valley." (USBR 2006a).

The five initial alternatives as identified within the SLWRI Environmental Scoping Report include:

- **No-Action (No Federal Action) –** Under the No-Action Alternative, the Federal Government would take no action through the assistance of Shasta Dam and Lake toward implementing a specific plan to help increase anadromous fish survival opportunities in the upper Sacramento River, nor help address the growing water reliability issues in the Central Valley of California.

- **Increase Water Supply Reliability with Shasta Enlargement –** The primary purpose of this alternative is to be consistent with the goals of the CALFED ROD, by increasing Central Valley Project (CVP) and State Water Project (SWP) water supply reliability while contributing to increased anadromous fish survival by increasing the height of Shasta Dam by 6.5 to 18.5 feet (increasing storage space in Shasta Lake by 290,000 acre-feet and 640,000 acre-feet, respectively). The increased pool depth and volume also may contribute to incidental benefits for flood control, hydropower, and outdoor recreation.

- **Increase Water Supply Reliability with Shasta Enlargement and Conjunctive Water Management –** The primary purpose of this alternative is to increase CVP and SWP water supply reliability through a combination of enlargement of Shasta Dam and Lake and conjunctive water management, consistent with the goals of the CALFED ROD. This plan is similar to the above initial alternative while including a conjunctive water management component consisting primarily of contract agreements between Reclamation and Sacramento River basin water users.

- **Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement –** The primary purpose of this alternative is to address both primary objectives with an emphasis on increasing anadromous fish habitat and enlarging Shasta Lake up to about 18.5 feet. In addition to increasing the cold water pool in Shasta Lake, this alternative includes the restoration of riparian and floodplain habitats at inactive gravel mines along the Sacramento River to help benefit anadromous fish.

- **Multipurpose with Shasta Enlargement –** This alternative also consists of raising Shasta Dam up to about 18.5 feet. In addition, to address the primary objectives, it includes conjunctive water management and restoring riparian and floodplain habitats within inactive gravel mine sites along the upper Sacramento River. Features that address the secondary objectives include constructing warmwater fish habitat in the Shasta Lake area, restoring one or more riparian habitat areas between Redding and Red Bluff on the Sacramento River, and possibly reoperating Shasta Dam for increased flood control.

Project Area

Reclamation has defined primary and extended impact areas. The primary area includes Shasta Dam and Lake, its tributary rivers and streams, including the upper Sacramento, McCloud and Pit rivers, Squaw Creek, and the Sacramento River from Shasta Dam to the Red Bluff Diversion Dam (PLATE 1). The extended area includes the Sacramento River and basin, other major tributaries downstream from Red Bluff, the Sacramento-San Joaquin Delta, the San Joaquin River basin, and the respective service areas of the CVP and SWP service areas (PLATE 2).

Related Considerations and Responsibilities

Water projects within the State of California do not operate in isolation. When operations of any one element within the CVP are significantly altered, wide-ranging effects on resource distribution, allocation, cost, and quality (often far afield from the immediate geographic locale of the specific project action) are probable. Additionally, many species of interest (e.g., anadromous fish and migratory birds) are geographically wide-ranging and biologically impacted by multiple interactive stressors. The interconnectedness of these biogeographic and resource management variables dictate agency planning should involve broader regional analyses and thorough examination of the breadth of potential direct and indirect impacts associated with the construction and management of water projects.

In support of its views, positions, evaluations, and recommendations, the Service provides the following background information on programs, plans, legislation, directives, and regulatory obligations pertinent to conservation of natural resources that could be affected by the SLWRI.

CALFED Bay-Delta Program

Enlargement of Shasta Lake is being studied as part of Stage 1 implementation of the CALFED Program. The CALFED Program is a consortium of 25 State and Federal agencies with resource management and regulatory responsibilities in the San Francisco Bay-Sacramento-San Joaquin-Delta estuary (Bay-Delta) and California's Central Valley. The mission of the CALFED Program, as stated in the ROD, is "to develop and implement a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta system" (CALFED 2000a). CALFED Program Solution Principles state that any CALFED action must:

- "*Reduce conflicts in the system*—Solutions will reduce major conflicts among beneficial uses of water."
- "*Be Equitable*—Solutions will focus on solving problems in all problem areas. Improvements for some problems will not be made without corresponding improvements for other problems."
- "*Have No Significant Redirected Impacts*—Solutions will not solve problems in the Bay-Delta system by redirecting significant negative impacts, when viewed in their entirety, within the Bay-Delta or to other regions of California" (CALFED 2000a).

The CALFED Program ROD selected the Preferred Program Alternative, which was also the Environmentally Preferable Alternative, defined in the ROD as “a set of broadly described programmatic actions which set the long-term, overall direction of the 30-year CALFED Program.” The Preferred Program Alternative includes the Levee System Integrity Program, the Water Quality Program, the Ecosystem Restoration Program (ERP), the Water Use Efficiency Program, the Water Transfer Program, the Watershed [management] Program, the Storage Program, and the Conveyance Program. The ROD also states that “Actions described are intended to take place in an integrated framework and not independently of one another. While each program element is described individually, it is understood that only through coordinated, linked, incremental investigation, analysis and implementation can we effectively resolve problems in the Bay-Delta system” (CALFED 2000a).

Included in the CALFED Preferred Program Alternative are the following commitments:

- “Develop[ing] appropriate groundwater and surface storage in conjunction with specified water conservation, recycling, and water transfer programs to provide water for the environment at times when it is needed most, and to improve water supply reliability.” (CALFED 2000a).

- “Decisions to construct groundwater or surface water storage will be predicated on compliance with all environmental review and permitting requirements, and maintaining balanced implementation of all Program elements.”

- “Subject to these conditions, new groundwater and surface water storage will be developed and constructed, together with aggressive implementation of water conservation, recycling, an improved water transfer market, and habitat restoration, as appropriate to meet CALFED Program goals. During Stage 1, through the water management strategy [WMS] (including the Integrated Storage Investigation [ISI]), CALFED will continue to evaluate surface water and groundwater storage, identify acceptable project-specific locations, and initiate permitting, National Environmental Policy Act (NEPA) and California Environmental Quality Act (CEQA) documentation, and construction if all conditions are satisfied” (CALFED 2000a:22).

An essential goal expressed by the CALFED Program is to increase water supply reliability, while also providing sufficient water to meet existing protection, restoration, and recovery efforts for fish of the Bay–Delta estuary (CALFED 2000a:54). To achieve this, the CALFED agencies committed to environmental measures pursuant to the Federal Endangered Species Act (ESA), California Endangered Species Act (CESA), and California Natural Community Conservation Planning Act (NCCPA) for the first 4 years of Stage 1, which were based on (1) the availability of water from existing environmental regulation, (2) an environmental water account (EWA) combined with the ERP, and (3) the ability to obtain additional water, as necessary.

The EWA–another component of the WMS– provides water for the protection and recovery of Bay-Delta fisheries through environmentally beneficial changes in CVP and SWP operations. EWA water is in addition to that already made available for existing regulatory requirements of CVP and SWP operations (CALFED 2000a). The EWA is intended to provide flexible, more efficient management of water operations that would provide beneficial habitat conditions needed for fish recovery, without relying strictly on regulatory prescriptions (CALFED 2000e). Water resources throughout the Delta's watershed could be accessed through banking, transferring, and borrowing water and arranging for its conveyance. These water "assets" could protect habitats for target fish species by increasing in-stream flows and minimize incidental take of listed species by reducing export pumping. (See Section 3.6.6 of the Phase 2 Report for a complete description of the EWA and its flexible water management approach).

The ERP is the CALFED Program's blueprint for restoration and recovery of fish and wildlife species, and the Multi-Species Conservation Strategy (MSCS) is the CALFED Program's conservation and regulatory compliance strategy (CALFED 2000a:77). The ERP includes actions throughout the Bay-Delta watershed, focusing on the restoration of ecological processes and important habitats to support sustainable populations of diverse plant and animal species (USFWS 2000). It is the premise of the MSCS that the CALFED Program as a whole, including all program elements, will improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta, with the ERP being the principal CALFED Program element designed to restore the ecological health of the Bay-Delta system (CALFED 2000a:77, USFWS 2000:19). The role of the MSCS in CALFED Program regulatory compliance is described below under *Associated Regulatory Responsibilities*.

Central Valley Project Improvement Act

Other legislation pertaining to development and operations of the CVP, and enlargement of Shasta Lake, includes the Central Valley Improvement Act (Title 34 of Public Law 102-575), enacted in 1992. The stated purposes of the CVPIA (section 3402) are to (a) protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California; (b) address impacts of the CVP on fish, wildlife and associated habitats; (c) improve the operational flexibility of the CVP; (d) increase water-related benefits provided by the CVP to the State of California through expanded use of voluntary water transfers and improved water conservation; (e) contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; (f) achieve a reasonable balance among competing demands for use of CVP water, including the requirements of fish and wildlife, agricultural, municipal and industrial and power contractors.

Section 3406 of the CVPIA amended CVP authorizations to include CVP purposes of "fish and wildlife mitigation, protection and restoration," and "fish and wildlife enhancement." The Secretary of the Interior (Secretary), represented by the Service and Reclamation, prepared a programmatic environmental impact statement (PEIS) (DOI 1999) and ROD (DOI 2001) for implementation of the CVPIA in accordance with NEPA.

To improve operational flexibility and water-related benefits of the CVP and achieve reasonable balance among competing demands for CVP water, the CVPIA provided for several reforms and provisions for CVP water management. These included: (1) new procedures, (2) approvals, and limitations for water contracting; (3) review and approval conditions for water transfers; (4) water metering requirements; (5) water pricing reform; (6) best management practices for water conservation; and (7) provisions for improvements of water conveyance facilities.

The CVPIA also provides several provisions for mitigation and restoration of fish and wildlife habitats and populations. These include: (1) replacement of ecologically equivalent fish and wildlife habitats, such as natural channel and riparian habitats; (2) efforts to increase populations of naturally produced anadromous fish; (3) increased water supplies for fisheries and refuges;

(4) mitigation plans and structural modifications for CVP facilities, such as pumping plants and diversions; (5) improvements to fish production facilities; and (6) biological monitoring.

Specifically, section 3406 (b)(1) of the CVPIA authorizes and directs the Secretary, in consultation with other State and Federal agencies, Indian tribes, and affected interests, to develop and implement a program which makes all reasonable efforts to at least double natural production of anadromous fish in California Central Valley rivers and streams[1]. Pertinent anadromous fish include Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), white sturgeon (*Acipenser transmontanus*), and green sturgeon (*A. medirostris*). Section (b)(1) further requires that this program give first priority to protection and restoration of natural channel and riparian habitats through habitat restoration actions, modifications to CVP operations, and implementation of the supporting measures mandated by the CVPIA (as referenced above).

The program developed for this directive was the Anadromous Fish Restoration Program (AFRP), with the Service as lead agency. The AFRP Plan (USFWS 2001) identifies the goal, objectives, and strategies of the AFRP, and identifies priority actions and evaluations to increase natural production of anadromous fish in the Central Valley of California. Significant components of the AFRP Plan include modifications to water control structures and operations, prescriptions for the magnitude and temporal pattern of instream flows in Central Valley streams, and preliminary targets for increased populations of anadromous salmonids.

The dedication of 800,000 acre-feet of CVP yield by the CVPIA has been an essential agency tool for pursuing AFRP goals of improved fish passage, habitat, and production. Section 3406 (b)(2) of the CVPIA dedicated this yield for the primary purpose of habitat restoration and measures authorized by the CVPIA. Other authorized uses of the 800,000 acre-feet of water include assisting California in the protection of waters of the Bay-Delta and meeting legal obligations, such as the ESA. The dedication of 800,000 acre-feet of (b)(2) water is an annual, ongoing activity that is used to help meet AFRP-recommended flows on CVP streams, assist in meeting water quality requirements, and for protection of listed species in the Delta.

To supplement the 800,000 acre-feet of dedicated CVP water, section 3406 (b)(3) provided that a program be developed and implemented to acquire additional water through means including improvements in, or modifications of, the operations of the project; water banking; conservation; transfers; conjunctive use; and temporary and permanent land fallowing, including purchase, lease, and option of water, water rights, and associated agricultural land. To date, due to limited water availability and increasing competition, inadequate water supplies have been available for acquisition.

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[1] CVPIA identified 1967 through 1991 as the base-period from which to calculate the average anadromous fish natural production for this purpose.

Another CVPIA provision providing for environmentally beneficial water supplies is found in section 3406 (d), which directs Interior to provide additional water for wetlands on Central Valley refuges and wildlife habitat areas. As provided in the CVPIA, the Secretary shall provide directly, or through contractual agreements, firm water supplies of suitable quality to maintain and improve wetland habitats on several designated refuges and wildlife habitat areas, Level 2 supplies for habitats set forth in Reclamation's Refuge Water Supply Report (USBR 1989a), and two-thirds of supplies needed for full development of habitats identified in Reclamation's San Joaquin Basin Action Plan/Kesterson Mitigation Plan Report (USBR 1989b). Section 3406 (d)(1) provides that in the absence of water contracts for refuge wetland uses, the Secretary shall still be obligated to provide the Level 2 supplies. Section 3406 (d)(1) also provides that the Secretary shall diversify sources of these water supplies to minimize possible adverse effects on CVP contractors. As further provided in section 3406 (d)(2), the Secretary, in cooperation with the State of California, shall deliver Level 4 water supplies for wetland habitats per Reclamation's Refuge Water Supply Report, and full supplies needed for full development of habitats per Reclamation's San Joaquin Basin Action Plan/Kesterson Mitigation Plan Report. This is to be accomplished through voluntary measures rather than involuntary re-allocations of project yield.

Related Projects, Actions, Plans and Initiatives

The principles and goals of the following programs and plans pertain significantly to the conservation of natural resources, including anadromous fish and their associated stream and riparian habitats, which could be affected by the SLWRI. The programs and plans are directed at restoring, enhancing, and recovering these resources, which have been adversely affected by water supply development and other human activities:

- Central Valley Salmon and Steelhead Restoration and Enhancement Plan (Reynolds, et al. 1990);
- California State Salmon, Steelhead Trout, and Anadromous Fisheries Program Act (California Senate Bill 2261, 1990);
- Proposed Recovery Plan for Sacramento River Winter-Run Chinook Salmon (NMFS 1997);
- Restoring Central Valley Streams: A Plan for Action (Reynolds et al. 1993);
- Status of Actions to Restore Central Valley Spring-Run Chinook Salmon (Mills and Ward 1996);
- Steelhead Restoration and Management Plan for California (McEwan and Jackson 1990); and
- Upper Sacramento River Fisheries and Riparian Habitat Management Plan (California Senate Bill 1086, 1989).

Associated Regulatory Responsibilities

Serving as the CALFED Program's Biological Assessment for ESA compliance and NCCP for NCCPA and CESA compliance, the MSCS submits several conservation strategy prescriptions and conservation measures for CALFED Program actions. The Service's Biological Opinion (USFWS 2000), National Oceanic and Atmospheric Administration (NOAA) Fisheries' Biological Opinion (NMFS 2000), and CDFG's NCCP Approval (CDFG 2000) adopted these prescriptions and measures, and further incorporated milestones to be achieved in the first 7 years of CALFED Program implementation. Milestones address biological functions and resources such as Bay-Delta hydrodynamics, Central Valley stream temperatures, Central Valley streamflow, natural floodplain and flood processes, and riparian and riverine aquatic habitats.

Various other plans and directives, in addition to specific terms and conditions enumerated within CALFED-associated and other pertinent biological opinions, should be consulted and evaluated within the context of the SLWRI water supply and modified operations, and adhered to accordingly. These include, but are not necessarily limited to, the following:

- Service CALFED Biological Opinion;
- National Marine Fisheries Service (NMFS) CALFED Biological Opinion;
- Service Operations Criteria and Plan (OCAP) Biological Opinion (USFWS 2005)[2];
- NMFS OCAP Biological Opinion;
- CVPIA PEIS Biological Opinion;
- NMFS Biological Opinion for winter-run Chinook salmon;
- Delta Smelt Biological Opinion;
- Service 5-Year Status Review for delta smelt (USFWS, Mar 2004);
- Sacramento-San Joaquin Delta Native Fishes Recovery Plan (USFWS, Nov 1996);
- NMFS findings associated with the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA)(NMFS, 2000)
- State Water Resources Control Board's Decision 1641 and related decisions.

In addition, the multi-agency Central Valley Technical Recovery Team, acting under the direction of NOAA Fisheries, is developing numeric population goals and specific actions for the recovery of winter- and spring-run Chinook salmon in the Central Valley.

[2] Currently under revision at request of Reclamation.

DISCUSSION

Project Area

The Service concurs with the expansion of the SLWRI project area to include the major tributaries to the Sacramento River, the Delta, San Joaquin River basin, and the respective service areas of the CVP and SWP as part of the "extended" project area (USBR 2006a). From the inception of the SLWRI, the Service envisioned the geographic scope of the SLWRI to include all of the lower Sacramento River Basin and Bay-Delta, and impacts within the CVP/SWP service areas such as potential agricultural or municipal/industrial growth that may be induced by additional Shasta Lake water supply (and/or facilitated by renewed or expanded water contracts). The entire CVP and SWP needs to be considered with modeling and other analyses to evaluate changes in operations due to Shasta Lake enlargement. Further, these changes subsequent to enlarging Shasta Lake should be evaluated within, and with respect to, OCAP revisions and the associated ESA review.

Project Analysis

The SLWRI identifies purposes of a final plan addressing water supply increase at Shasta Lake as: (1) increased survival of anadromous fish populations in the upper Sacramento River, (2) increased water supply reliability, and to the extent possible through meeting these objectives, (3) include features to benefit other identified needs of the ecosystem, flood control, and water resources. The suite of options selected to address these objectives will require adequate evaluation to identify the environmentally-preferred action and enable justifying a preferred project.

We believe a complete suite of options for the SLWRI should include the concepts of new storage facilities (of which the enlarged Shasta Dam has been identified as one of five to evaluate further) and actions that can effectively reduce demand in order to increase reliability of existing supplies.

Potential improvements to water supply reliability for the CVP and SWP will require integrated analysis across the entire CVP/SWP watershed. Analyzing single components within the system could present an incomplete or inaccurate picture. Therefore, the Service recommends a broad and inclusive analysis for the SLWRI that takes into account water needs and usage across the entire CVP/SWP watershed and includes all associated interconnected regulatory responsibilities, objectives, and mandates, including those found in CALFED and CVPIA processes and decisions, as described in more detail below.

The Service further encourages Reclamation to provide clarification in the SLWRI feasibility and environmental review process, regarding the purpose and use of increased yield from a potential Shasta Dam enlargement. The quantity and allocation, on a year-to-year basis, of such increased yield should be explicitly defined. Would this increased water supply reflect water available for new contracts? Is it intended simply to improve reliability of existing water contracts? What portion would be managed for environmental benefits? With anadromous fisheries restoration as a clear and primary goal of a Dam elevation raise, how would an increase in yield be allocated towards enhancement and augmentation of this resource?

It is to be expected that flow regimes in the Sacramento River would change with an enlarged Shasta Dam. Presuming additional flood control would not be a primary objective served by the new capacity, it is reasonable to predict that flows would decrease during certain times of the year as additional water is stored. This volume would then be shifted to other periods of the year when certain water demands are more critical. In general, as per existing operations, we assume fall drawdown and winter peak flows would decrease, and late spring/summer flows would increase. The timing and extent of this shift in flows and releases should be predicted and included in the projection of effects from the enlarged Shasta Dam on the Sacramento River and the Bay-Delta.

Further, the timing and nature of releases within the intensively managed CVP/SWP may have impacts on associated programs, such as the EWA and refuge water supply. The inter-relatedness of these programs with changes in flow regimes subsequent to a Shasta Lake expansion should be carefully anticipated and included in detailed analysis in order to properly factor in all possible impacts from a change in dam elevation.

The CALFED alternative selection process concluded that "[W]ater use efficiency must be strongly pursued in all the alternatives" (CALFED 2000a). As a result, we believe to accurately assess water supply benefits of increased Shasta storage, it is first necessary to evaluate the effect of implementing all other means of increasing CVP yield, including: (1) conjunctive use, (2) water conservation and efficiency measures, (3) water transfers, and (4) recycling.

Consideration of Other Actions

The CALFED ISI is evaluating five different water storage projects as possible solutions to the water quality and water supply reliability dilemma. Assessment of SLWRI effects should include consideration of how other new projects could be implemented in conjunction with Shasta Lake enlargement. Various off-stream reservoir storage projects have been evaluated in previous studies. All but one of these storage projects were eliminated from further consideration in the CALFED ROD, primarily due to project cost considerations, potential environmental impacts, and lands and relocation issues. The one project retained for further consideration was Sites Reservoir, with a storage capacity of up to 1.8 million acre-feet.

DWR is studying Sites Reservoir and its alternatives under the North of Delta Off-stream Storage (NODOS) Project. Sites Reservoir could be filled primarily by water diverted from the Sacramento River and tributaries during periods of excess flow through the Tehama-Colusa Canal, Glenn-Colusa Irrigation District Canal, and/or a new pipeline near Maxwell. Another potential source of water for filling this reservoir could be moving (pre-delivery) Tehama-Colusa Canal Authority and Glenn-Colusa Irrigation District water from Shasta Lake during the spring and storing it at Sites Reservoir for delivery during the irrigation season. Reclamation received Federal feasibility study authority for NODOS in section 215 of PL 108-7 in September 2003. NODOS has the potential to increase the water supply reliability of Sacramento Valley users, the SWP and CVP, and improve Delta water quality, contribute to ecosystem restoration and provide water to support the EWA.

Current alternatives in SLWRI analysis view the Shasta Lake enlargement in isolation. In actuality, benefits of Central Valley surface storage projects are dependent on all other associated actions, including operations of other Central Valley reservoirs and water transfers and exchanges. Actual benefits to fisheries and water deliveries depend upon contributions of other projects and actions in combination with the Shasta Dam enlargement. Therefore, the Service recommends SLWRI analyses consider other potential surface storage projects (e.g., Sites Reservoir) and its effect on water supply in cumulative analysis. To date, other alternative storage options for consideration include: Los Vaqueros Reservoir expansion, Delta Islands development, Upper San Joaquin Basin development, and Folsom Lake enlargement.

Some potential strategies for joint operations of Shasta Lake with other potential facilities include utilizing NODOS as a substitute water source for some purposes, as available, so that Shasta Lake could conserve water for cold water flows. Additionally, Shasta Lake could provide water as substitute supplies for Folsom Lake water. Folsom Lake water could then be preserved for lower American River flow needs and water quality needs in the Delta. These types of exchanges, as they fit within the larger ISI and current CVP/SWP operations, should be discussed and coordinated within and between the various investigations, including the SLWRI.

Relationship to CALFED

The SLWRI's relationship to the CALFED program remains unclear, and should be more clearly established. The initial Alternatives Reports (USBR 2004a; USBR 2004b) indicated a weak link to CALFED. Responding to public comments questioning the consistency of SLWRI with CALFED, the Environmental Scoping Report (USBR 2006a) states,

> "Although the SLWRI is not tiering off the CALFED ROD, the goals of the study are believed to be consistent with the goals of CALFED. In addition, SLWRI planning principles maintain that 'Primary consideration should be given to recommendations in the CALFED ROD,' and 'Alternatives should be formulated to neither preclude nor enhance development and implementation of other elements of the CALFED program or other water resources programs and projects in the Central Valley."

The Service believes the SLWRI is a CALFED directed action. As such, adherence to the principles and provisions of CALFED are inherently and unequivocally intertwined with the SLWRI planning process. These same planning processes and associated decision documents should specifically commit the SLWRI to meeting CALFED objectives and improving the CALFED-related benefits of its environmental objectives. The commitment to ecosystem restoration in the SLWRI mission statement should clearly be incorporated into the alternatives and environmental analyses in a manner that addresses the relationship of the Shasta Dam elevation to the larger CALFED perspective (i.e., defining precisely how an enlarged Shasta Lake fits into the extended planning area, and justifying this particular solution relative to other prospective solutions).

The CALFED Program provided a Plan for Action for the first 7 years (Stage 1) of a 30-year (or more) program following issuance of the ROD, and builds the foundation for long-term actions

(CALFED 2000a). The Plan for Action states, “Storage projects are not developed in isolation but rather as part of an overall water management strategy” (CALFED 2000a). The CALFED Program MSCS adds that “...the multiple benefits derived from water management actions are most clearly demonstrated if these actions are described in terms of coordinated water management throughout the Bay-Delta system.” This coordinated implementation is referred to as the CALFED Water Management Strategy, which the Service believes should be further developed and implemented to assess water storage projects, including SLWRI.

Given the premise of the MSCS is that all Program elements will improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta, and the overall CALFED principle that solutions will focus on solving problems in all problem areas in an equitable fashion, all CALFED programs (including surface storage) are expected to provide tangible ecosystem benefits. CALFED’s intent is to have ecosystem and other CALFED purposes get better together. Therefore, the integration and relationship of the Shasta Dam Enlargement and associated operations must be addressed in light of the directives of the CALFED MSCS, ERP, EWA, and an overall WMS.

The CALFED ROD determined that the ERP, to be successfully implemented, must have at least $150 million from dedicated funding sources annually through Stage 1 of the CALFED process. The ROD also identified an additional $50 million annually to fully fund the EWA for the first 4 years. However, EWA funding has not yet reached this level. EWA funding through the end of Stage 1 has been less than anticipated. To the extent that the EWA acquires a share of new storage and conveyance projects, the need for EWA funding for annual acquisitions of water may continue to be less than that anticipated in the CALFED ROD. On July 16, 2004, Reclamation, on behalf of the CALFED agencies, formally requested reinitiation of consultation on evaluation of the efficacy of the EWA and progress toward achieving ERP milestones. The Service determined that the EWA had reduced the direct effects of water exports on fish and protected the SWP and CVP from water supply impacts due to export curtailments for incidental take. The Service also determined that, while not fully funded, the EWA had implemented most of the desired actions in the first 4 years, and additional funding could enable the EWA to implement more upstream actions and potentially make some water available for experiments. However, implementation could be improved, and some questions remain unanswered as to the population-level effects of incidental take (loss of fish at major diversions), including: (1) how much water is needed to successfully implement EWA goals; and (2) how best can the EWA contribute to species protection and recovery?

Source shifting agreements with south-of-Delta water providers for 100,000 acre-feet of water supplies have been used to enhance the effectiveness of the EWA, and to help provide assurance that SWP and CVP water deliveries and operations will not be affected by EWA operations. As CALFED develops new water, the EWA is expected to obtain an appropriate share in order to minimize the need for annual acquisitions and to maximize operational flexibility (CALFED 2000a).

The Service believes that these provisions in the CALFED ROD, in conjunction with the fact that the SLWRI is envisioned as a CALFED-directed action, indicate that part of the realized yield from an enlarged Shasta Dam and Lake should be allocated to meeting the EWA’s recognized need for water assets and secure storage. Further, it should be clear that these allocations would be supplemental to water already prescribed to address baseline environmental demands (e.g., winter-run Chinook salmon and delta smelt protections under ESA, and Delta water quality standards). The CALFED ROD (CALFED 2000a) directs that the EWA will provide for fishery protection actions that are supplemental to a baseline level of protection established by an existing set of regulatory programs.

Relationship to CVPIA

The Service sees significant overlap between the objectives and directives contained within the CVPIA and actions related to the SLWRI. The objectives to "protect, restore, and enhance fish, wildlife, and associated habitats" and to "achieve a reasonable balance among competing demands for use of CVP water, including the requirements of fish and wildlife…," among others, are directly relevant. Additionally, CVPIA directives, such as section 3406(b)(1)—to at least double natural anadromous fish production and to give first priority to protection and restoration of natural channels and riparian habitats through modifications to CVP operations—must be part of the SLWRI analysis to determine the specific impacts of Shasta Dam elevation and operation within these mandates.

Similar to provisions of the CALFED ROD, the CVPIA identifies CVP purposes to include improving CVP operational flexibility and increasing water-related benefits through transfers and water conservation, and to contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, among others. The CVPIA also provided tools to carry out these purposes, such as best management practices for water conservation. These CVP purposes and CVPIA provisions should be analyzed, along with the CALFED directed WMS approach, for the SLWRI's effects on the Service-recommended region-wide analyses and alternatives assessments for the SLWRI.

SLWRI analysis should also describe project operations and water accounting so as to avoid any effects on the use of dedicated fishery water as provided under section 3406(b)(2) of the CVPIA. These operations should then be incorporated into the detailed project description.

Water supply reliability is an essential factor behind management decisions about how to prioritize the allocation of water between competing beneficial uses. Increasing supplies system-wide should accrue benefits to each respective beneficiary in direct proportion to the priority-based weighting of those benefits by the supplier. Accordingly, we believe careful consideration should be given to environmental water needs and benefits (as per the various environmentally related laws[3], mandates, programs, plans, and goals and objectives described in this memorandum) when determining benefits priorities and water allocations for SLWRI.

[3] Including, but not limited to, the ESA, MSFCMA, NEPA, CEQA, CVPIA, and Fish and Wildlife Coordination Act which requires Federal agencies proposing water development projects to consult with the Service and provide equal consideration to the conservation, rehabilitation, and enhancement of fish and wildlife resources with other project purposes.

Section 3406(a)(2) of the CVPIA amends the CVP Authorizations Act of 1937 to include fish and wildlife protection, restoration, and mitigation as project purposes of "equal priority" with agricultural and domestic water supply, and fish and wildlife enhancement as a project purpose equal to power generation. Some portion of the yield from an enlarged Shasta Lake therefore should be committed to help meet this amended Project authorization by providing for fish and wildlife protection, restoration, mitigation, and enhancement. This "equal priority" should be considered in more literal terms to reflect a percentage of realized yield from an enlarged Shasta Lake. We believe when CVPIA directives, primary objectives outlined in this investigation, and the SLWRI Mission Statement are considered together, an environmental allocation percentage should be considered close to 50-percent of realized yield. Lastly, because SLWRI planning processes should not limit possible decisions stemming from system-wide analyses, we recommend outside-brackets be modeled including 100-percent use of additional yield for environmental purposes, and 100-percent use to meet supply reliability needs. The task of the SLWRI process then becomes that of defining any realized yield on a year-to-year basis (with all appropriate variables incorporated to the models), and its partitioning as part of a programmatic water management strategy to meet the investigation's "mission", and existing commitments, policies and regulations within the primary and extended project areas.

<u>Relationships to Other Regulatory Responsibilities and Commitments</u>

In addition to biological opinions regarding CVP operations, other regulations and plans require water management actions to benefit fish and related species and habitats and should be included as baseline conditions (i.e., new water supplies resulting from storage and other water management actions should be in addition to existing environmental water allocations). Other regulations and plans include, but are not limited to:

- 1993 Winter-Run Biological Opinion (NMFS);
- 1995 Delta Water Quality Control Plan (SWRCB) and Related Decisions;
- 1995 Delta Smelt Biological Opinion (USFWS);
- Vernalis Adaptive Management Plan; and
- Full Use of 800,000 acre-feet of Water Supply Pursuant to Section 3406(b)(2) of the CVPIA.

The environmental baseline elements above also assume that other environmental protections contained in statutes remain in place. These other environmental protections include, without limitation, Level 2 refuge water supplies, as required by the CVPIA. Accordingly, we assume the CVP will continue to use its share of benefits from the Joint Point of Diversion, to the extent available, to provide water required by its Level 2 refuge water supply mandates, but using such benefits will not create any limitation on the Level 2 supply available for refuges.

Anticipated Fish, Wildlife and Habitat Impacts

Implementation of the proposed project or alternatives would result in impacts to natural resources, including: (1) aquatic resources—changes to Shasta Lake elevation; backwater ponds; downstream flows; and water quality including water temperatures, (2) fish and wildlife resources, and (3) vegetation communities.

The Service will more completely analyze impacts of the SLWRI in our forthcoming FWCA Report. Some project impacts are being evaluated using the Habitat Evaluation Procedures (HEP). HEP is a methodology developed by the Service and other resource and water development agencies for documenting the quality and quantity of available habitat for selected fish and wildlife species. The cover-types that are being surveyed and evaluated in the HEP application are: (1) blue oak-gray pine, (2) blue oak woodland, (3) closed-cone pine-cypress, (4) mixed chaparral, (5) montane hardwood-conifer, (6) montane hardwood, (7) ponderosa pine, (8) Sierran mixed conifer, and (9) montane riparian.

Following are lists of impacts or potential impacts associated with a Shasta Dam elevation change. This list is not intended to be exhaustive, and it does not follow that all are significant from an ecological perspective. These are highlighted herein in the interest of assisting with a comprehensive environmental analysis. The relative influence and severity of the following potential impacts should be incorporated into the SLWRI planning process and development of SLWRI environmental compliance studies and documents.

Upper Sacramento River

Water Quality Impacts

- Effects from dam releases with changes in lake limnology, including turbidity, temperature and nutrients
- Sedimentation in Keswick Lake (and Sacramento River)
- Nutrient cycling in Keswick Lake (and Sacramento River)
- Impacts to dilution inflows for acidic drainage from Iron Mountain Mine into Keswick Lake, and
- Temperature benefits for fish

Flow-Related Impacts

- Reduction in Sacramento River flushing flows during peak flood events
- Influence upon channel aggradation, degradation, incision rates
- Potential for cutbank loss (loss bank swallow habitat)

- Floodway channel conditions, including width, roughness, bank stability, erosion, and floodwater velocity
- Flow benefits for fish
- Re-establishment of former channel segments/oxbows/floodplain (benefit)
- Wetland recharge during reduced instream flows during summer, and
- Flow-effects on water supplies for Refuge management activities

Colusa-Sacramento River SRA

- Lower winter flows reduce Shaded Riverine Aquatic (SRA) habitat maintenance (debris deposition and vegetation growth)
- SRA--lower winter flows reduce access by fish, increase predator habitat, and affect fish passage in the Sacramento River

Vegetation (wetland, riparian, upland habitats)

- Loss of riparian cover (reduced winter flows)
- Possible nonnative vegetation encroachment from reduced winter flows (loss of instream habitat)
- Effects to vegetation including, composition, age structure, quantity, growth, vigor, soil fertility/seed bed formation and quality, and regeneration/succession of riparian vegetation
- Inundation duration, frequency, elevation in vegetation zones, including
  - Excess mortality by erosion
  - potential impacts of longer summer inundation
  - potential impacts from shorter winter inundation, and
  - groundwater availability for plants during reduced instream flows

Expanded Project Area--Delta

- Changes in Bay-Delta flushing flows during winter months
- Delta water quality (e.g., X2 locations, contaminant dilution)
- Delta outflow
- Delta inflow/export ratios

- Delta conditions relative to pelagic organisms decline

Expanded Project Area—CVP/SWP Service Area

- Water deliveries and growth inducement (M & I)
- Water deliveries and agricultural expansion

Shasta Lake and Tributaries and Adjacent Habitat

<u>Limnology (in lake)</u>

- nutrient composition
- nutrient cycling

<u>Stream channels (tributaries to lake)</u>

- changes in channel location
- channel geometry (cross sectional shape, width, depth)
- slope
- form (straight, meandering, braided)
- turbidity, temperature, nutrients
- erosion, sedimentation
- sediment loading/deposition in lake-inundated parts of channel (USFS)
- sliding of hillsides into creek/reservoir due to inundation (mass wasting/slide analysis—USFS)
- channel aggradation, degradation, incision, cutbanks
- SRA cover
- predator habitat for stream fish

<u>Vegetation (wetland, riparian, upland)</u>

- vegetation composition, age structure, quantity, vigor
- soil fertility/seed bed formation/quality

- regeneration/succession
- mortality by erosion, flooding
- inundation duration, frequency, elevation
- groundwater availability for plants
- loss of snags around lake (e.g., osprey nests)
- loss of bald eagle nesting trees

Contaminants

- mines — acid mine drainage, contaminated tailings piles around lake
- mercury — transfer to fish

Species Potentially Affected

Numerous fish and wildlife resources and special status species may be affected by the proposed project. In addition to federally and State listed species, refer to the CALFED MSCS for a comprehensive list of covered species and NCCP communities to be included in the effects analysis.

Species Protected Under the Endangered Species Act

Attached is an unofficial list of Federal endangered and threatened species that occur in or may be affected by the proposed project (see attached). To obtain an official Service list, refer to the Service's Sacramento Fish and Wildlife Office website, (http://www.fws.gov/sacramento/) for a current list of protected species that may occur in or may be affected by the proposed project. Also, to obtain a list for species protected under the jurisdiction of NOAA Fisheries, write to Mr. Michael Aceituno, c/o NOAA Fisheries Service, Sacramento Area Office, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814-4706

Potential Mitigation

The Service has tentatively identified the following measures as possible means for mitigation for some of the SLWRI-associated impacts. Where applicable, these and other appropriate mitigation measures that avoid, minimize, and compensate project effects should be incorporated into SLWRI planning processes, environmental compliance studies and documentation.

- Leave trees/shrubs in Shasta Lake inundation zone for fish/wildlife habitat use.
- Potentially assist management of PG&E facilities to enhance stream habitat and flow on tributaries to Shasta Lake.

- Remediate and restore mining sites and forest areas around and near Shasta Lake (e.g., treat soils to reduce acidity, plant vegetation, clean up creeks, and eliminate acid mine drainage, etc.).

- Sacramento River corridor habitat enhancement (e.g., riparian, wetland, and other habitats, possibly at Sacramento River Conservation Area, and other sites).

- Emphasize listed species recovery with project mitigation (consistent with CALFED ERP goals).

- Implement, as suitable for mitigation for Shasta Lake impacts, secondary objectives pertaining to fish and wildlife in Reclamation's SLWRI Alternatives Report.

- Implement a coarse sediment addition project that would sustain gravel and sand loads in the Sacramento River by addition sand and spawning-sized gravel on a regular basis and at a much larger scale to better mimic natural sediment loads and therefore provide the sediment from which the river would naturally create and maintain spawning riffles.

- If the Shasta project is going to improve downstream conditions for fish, then Reclamation needs to resolve the fish passage problems at the Red Bluff Diversion Dam so fish can take advantage of improvements downstream of the Shasta Dam and in Battle Creek, which is slated for instream habitat restoration.

- Create and/or enhance bat habitat by modifying entrances to abandoned mine shafts in the lake area (e.g., install bat gates to allow bat passage but block human access.

It is critical that mitigation sites and strategies be identified early in the planning process. This will allow for a more thorough analysis and incorporation within the HEP application.

Recommended Studies (partial list)

The Service recommends studies continue or are initiated as part of the SLWRI, to help support feasibility and effects analyses as discussed above. These studies should be in the following categories:

- Water Quality
    - limnology, streams (temperature, dissolved oxygen, contaminants, etc.)
    - copper mine sites in inundation area
    - nutrients/plankton in Shasta Lake (before and after lake enlargement)
    - effects downstream in Keswick Lake (and Sacramento River)
    - CE-QUAL-2 should be completed for Shasta Lake water quality
- Water Quantity and Cost – complete CALSIM II modeling for water supply benefits and cost allocations.

- Temperature Control Device - Incorporate Shasta Lake temperature control device warm water leakage into modeling, including calibration for dry or low pool conditions

- Flood Control - Evaluate opportunities to minimize structural flood control actions on the Sacramento River.

- Natural Hydrograph Benefits – Evaluate natural resource benefits of more frequently retaining high winter flows within the Sacramento River and Bay-Delta aquatic, wetland, and riparian habitats.

Suggestions for the SLWRI Feasibility Analysis

Analysis Under No Action

Reclamation has identified that under the No Action Plan (alternative) they, "…would take no action toward implementing a specific plan to help increase anadromous fish survival opportunities in the upper Sacramento River, nor to help address the growing water reliability issues in the Central Valley of California." It is not clear to the Service whether this definition precludes management actions and operations without dam elevation. As Reclamation is aware, certain actions for anadromous fisheries and associated habitats are already mandated by applicable regulations and policies (e.g., CVPIA and ESA). It should be clarified, within SLWRI analysis, which actions, goals and objectives are already the responsibility of the Federal Government in the extended planning area, and are thus to be expected under the No Action scenario.

The Service believes the following activities are expected to take place, or should occur, with or without Shasta Lake expansion: (1) continued implementation of water use efficiency and conservation, (2) Joint Point of Diversion exchanges between the CVP/SWP, (3) supply augmentation via land retirement (e.g., the San Luis Drainage Feature Re-Evaluation [USBR 2006b]), (4) water transfers, (5) recycling, (6) Delta-Mendota Canal/California Aqueduct Intertie, (7) implementation of the EWA, and (8) Banks Pumping Plant expansion. These ongoing and anticipated projects should be included in modeling for all SLWRI alternatives, including the No Action. To date within SLWRI planning documents reviewed by the Service, it is not clear how or if these activities were considered in modeling efforts.

<u>Analysis of Action Alternatives</u>

As presented, SLWRI's only explicit commitments to ecosystem improvement are restoration of unidentified inactive gravel mines and floodplain habitat in two of the five alternatives, and the incidental benefit of an expanded cold water pool in Shasta Lake. Given the existing requirements and commitments, we believe all action alternatives should provide environmental benefits and that benefit range should extend beyond that currently identified. As is currently the case, restricting fisheries benefits to increases of cold water pool in the 18.5-foot dam raise alternative gives water supply precedence over fish and wildlife needs, which we feel to be contrary to CALFED and CVPIA guidance. It should be clarified quantitatively if, when and how the incidental effect of the expanded cold water pool would benefit anadromous fish.

Given these considerations, the Service recommends a thorough analysis, incorporating a suite of options to meet fisheries restoration needs, with explicit details regarding the anticipated use of Shasta water and the proposed mechanism for anadromous fisheries restoration in the Upper Sacramento River. If the anticipated restoration mechanism is enhancing fish spawning potential, this must be spelled out within the feasibility analysis. The Service further recommends that the variables and assumptions feeding the CALSIM and SALMOD modeling efforts be clearly delineated in final reports, with clear indication of the statistical power inherent in each—to indicate both the quantitative and qualitative extent of expected benefits, and the associated confidence intervals for each analysis. The influence of modified operations (i.e., specifically using the expanded cold water pool associated with different levels of dam raise to maximize fisheries benefits) upon these benefits should also be integrated within the analysis.

The Service further recommends that the alternatives analysis include an assessment of the benefits of repairing/upgrading the Shasta Lake temperature control device (to maximum practical extent), and that this action should be a part of all alternatives (analyzed with and without dam raise alternatives).

The impact of optimizing water management without an enlarged Shasta Dam should also be analyzed to compare to alternatives that involve raising the dam. This analysis should identify benefits to both water supply and instream temperatures and survival for fish. Specifically, the impact of (and potential for) increasing winter carryover storage and related storage and release measures should be included within the analysis to assess management strategies as a means to realize fisheries benefits short of a change in dam elevation.

While these elements may not directly meet both primary objectives of the SLWRI, their analysis should help better define the need for the SLWRI as a means to meet either objective. Actions that restore and maintain the natural environment—consistent with the objectives and intent inherent in provisions of CALFED, CVPIA, ESA and CWA, can increase water supply reliability by avoiding disruption of water delivery for the purpose of protecting declining fish populations.

Incorporating the discussion above, the Service recommends that Reclamation analyze an alternative specifically designed to maximize fish and wildlife benefits in order to meet protection, restoration, mitigation, and enhancement commitments and objectives. Reclamation should identify the full range of benefits that might be possible by raising Shasta Dam for all uses, including anadromous fisheries restoration. The Service recommends that this alternative include the following: (1) Reclamation should draft, with the Service and NOAA Fisheries assistance if necessary, specific protection, restoration, mitigation, and enhancement objectives, considering all existing regulations, policies, commitments and decisions, so that modelers can assess benefits of the project, and (2) Reclamation should determine the water supply needed to reach these objectives. Finally, the Service recommends inclusion of a range of water specifically dedicated for fish and wildlife purposes within SLWRI alternatives. The ability of quantities within this range to meet existing fish and wildlife needs should be discussed and related to these existing regulations, policies and decisions.

RECOMMENDATIONS

In summary, given all relevant considerations, the Service recommends within the SLWRI planning process, that Reclamation:

1) Evaluate the relationship of the effects of actions affiliated with the proposed SLWRI Project within primary and expanded project areas in the context of existing and relevant Biological Opinions.

2) Incorporate the principles and goals of relevant plans and statutes as outlined above (in "**Related Projects, Actions, Plans and Initiatives**," page 10).

3) Consult and integrate the SLWRI with relevant CALFED-related Opinions and Objectives, including: the CALFED ROD Biological Opinion, the OCAP Biological Opinion, and the Service's Delta Native Fishes Recovery Plan.

4) Integrate the SLWRI analysis across the entire watershed, consistent with the interconnectedness associated with all major water projects within the larger CVP/SWP.

5) Clarify the intended use of increased yield from an enlarged Shasta Lake—provide specific operational commitments and details regarding the nature and timing for allocation of project benefits (water supply).

6) Evaluate fully the beneficial or detrimental influences an enlarged Shasta Lake will have on the EWA, AFRP flows and refuge water supply.

7) Fully evaluate and implement demand reduction measures to effectively increase water reliability short of dam elevation.

8) Evaluate construction and operation of an enlarged Shasta Lake within the larger context of the entire ISI, including the potential strategies for joint operations to best meet project objectives.

9) Fully integrate the objectives of CALFED into the SLWRI and ensure that operation and management of an enlarged Shasta Lake is aligned with CALFED. These considerations include the goals and regulatory responsibilities associated with the MSCS, ERP, and EWA within the larger WMS.

10) Evaluate allocation of a portion of the increased storage from an enlarged Shasta Lake to meeting EWA demands.

11) Integrate the SLWRI with CVPIA objectives, including provision of AFRP flows, b(2) requirements, and Refuge Level 2 and Level 4 water supplies.

12) Include among the suite of alternatives (within what is currently identified as "Comprehensive Plan 4, Mini-Raise, Environmental Restoration and Enhancement) an alternative that fully evaluates management of an enlarged Shasta Lake to meet fish and

wildlife restoration and enhancement objectives. This alternative should specifically address the supply necessary to meet established recovery goals, and how allocation from an enlarged Shasta Lake could meet this demand.

13) Include in alternative analysis, an assessment of benefits of repairing/upgrading the Shasta Lake temperature control device (to maximum practical extent), and (if deemed practical) this action should be a part of all alternatives analyzed.

14) Analyze the potential for optimizing water management without an enlarged Shasta Dam.

15) Equally compare alternatives that involve raising the dam and include benefits for both water supply and fish and wildlife.

16) Incorporate fish-focused benefits into all action alternatives beyond the incidental benefit of an enlarged cold water pool with explicitly defined management guidelines.

17) Ensure that the potential impacts identified above (**Anticipated Fish, Wildlife and Habitat Impacts**, page 17-20) are considered within the SLWRI planning process.

18) Anticipate, qualitatively or quantitatively (where appropriate) the impacts to potentially-affected species, as above (**Species Potentially Affected**, page 20). Include these impacts and any mitigating measures in all planning processes.

19) Ensure the results of surveys and studies recommended in **Recommended Studies** (page 21) are incorporated through the SLWRI process, to the extent that these are not yet initiated and ongoing.

20) Evaluate potential mitigation strategies for the project, including those enumerated above (**Potential Mitigation**, page 20), and incorporate into planning processes.

21) Identify mitigation sites and/or strategies as soon as practical in order for the Service to complete the HEP analysis and incorporate the existing habitat utility measures collected during the HEP surveys.

CONCLUSION

As a logical course of evaluation, the Service recommends the SLWRI begin with assessing and implementing demand management and reduction measures to the maximum practical extent. Evaluation of additional storage facilities can then evaluate supplies to the extent there are remaining demands, while the feasibility analysis underpinning the permitting and construction of these projects would evaluate how these projects will integrate within the operation of the entire system. Such an approach would provide a firm basis from which to assess water supply availability and reliability, and thereby provide a strong underpinning for future decisions regarding CVP water supplies, including those for water contracts. The Service believes such an approach would be the most prudent strategy within the larger context of the SLWRI, and that this systematic analysis and step-wise methodology would be the most logical and defensible course of action.

Increased water supply from an enlarged Shasta Lake should be managed to provide biological benefits. An enlarged cold water pool, one of these benefits, is only incidental to an enlarged reservoir. It is not apparent whether operations of the enlarged reservoir would be conducted specifically for fishery benefits, other than operation of the modified Temperature Control Device.

A portion of an increased Shasta Lake water supply should be dedicated to biological benefits in a way similar, but additional to, the dedicated 800,000 acre-feet provided for by the CVPIA. How this water would be allocated and managed needs to be determined. The Service offers its assistance to Reclamation to incorporate these elements into the SLWRI analysis and modeling.

At this stage of analysis, it is sufficient to outline some potential objectives which water from an enlarged Shasta may be dedicated to meeting. Several of these have already been outlined within CALFED provisions relative to the ERP, MSCS, relevant Biological Opinions from the Service and NOAA Fisheries, and the NCCP Determination. These include:

- Meeting the ERP milestones for recovery of Chinook salmon and steelhead (CALFED Phase I condition of Biological Opinions and NCCP Determination).
- Meeting the ERP milestones to benefit covered fish species.
- Meeting obligations for water supply under the EWA.
- Creating secure storage for EWA assets.
- Meeting CVPIA AFRP flow standards (which are not always met on the Sacramento River).
- Meeting steelhead flow requirements and other flow needs for the lower American River and AFRP.
- Meeting Delta water quality requirements. (Trinity River import reductions exacerbate this condition).
- Providing Refuge water supplies for Level 2 and Level 4 water.
- Providing flow releases that better simulate natural seasonal flows and increased flows at various times of year to provide more suitable fish habitat and water temperatures. (See ERP proposed actions in Table D-1 of the Service’s Programmatic Biological Opinion for CALFED).

The Service appreciates the opportunity to participate in the early planning stages of project planning for the SLWRI. If you have any questions regarding this memorandum or our recommendations, please contact Mark Littlefield of my staff at (916) 414-6600.

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APPENDIX D

CALFED Multi-Species Conservation Measures for the

Shasta Lake Water Resources Investigation

Sacramento Fish and Wildlife Office

U.S. Fish and Wildlife Service

<u>Multi-Species Conservation Strategy Species that may be affected by SLWRI</u>

Purpose: Summarize the MSCS species that may be affected by the SLWRI and their conservation measures as recommended by the CALFED Final EIS/EIR (July 2000)

Near Shasta Lake

Goal	Common Name	Scientific Name	Status	Habitat
r	California yellow warbler	*Dendroica petechia brewsteri*	CSC	VFR, MR
r	Little willow flycatcher	*Empidonax traillii brewsteri*	SC	VFR, MR
m	Shasta salamander	*Hydromantes shastae*	CT, SC	VFW, MW
m	Shasta sideband	*Monadenia troglodytes*	SC	MW
m *	Shasta snow-wreath	*Neviuisia cliftonii*	1B	VFW, MW
m *	Shasta clarkia	*Clarkia borealis* spp. *arida*	1B, SC	VFW
m	Silky cryptantha	*Cryptantha crinita*	1B, SC	VFR, MR, GR, VFW, MW
m *	Bellinger's meadowfoam	*Limnanthes floccosa* ssp. *bellingeriana*	1B, SC	VFW, NTFE
m	Thread-leaved beardtongue	*Penstemon filiformis*	1B, SC	VFW, MW
m	Northwestern pond turtle	*Clemmys marmorata marmorata*	CSC, SC	VFR, L, MR, NTFE, R
m	Foothill yellow-legged frog	*Rana boylii*	CSC, SC	VFR, MR, R
m	Bald eagle	*Haliaeetus leucocephalus*	PR, CE, FP	MR, VFR, MW, L, R
m	Golden eagle	*Aquila chrysaetos*	PR, CSC, FP	VFR, G, US, VFW
m	Northern spotted owl	*Strix occidentalis caurina*	FT	MW
m	California red-legged frog	*Rana aurora draytonii*	FT, CSC	L, MR, VFR, NTFE, R
m	Ringtail	*Bassaricus astutus*	FP	MR, VFR, US, VFW, MW
m	American peregrine falcon	*Falco peregrinus anatum*	CE, FP	L, NTFE
m	Greater western mastiff-bat	*Eumops perotis californicus*	CSC, SC	MR, VFR, GR, S, VFW, MW
m	Long-eared owl	*Asio otus*	CSC	MR, VFR, VFW
m	Osprey	*Pandion haliaetus*	CSC, SB	MR, VFR, VFW, MW, L, R
m	Great blue heron	*Ardea herodias*	SC	MR, VFR
m	Rough sculpin	*Cottus asperrimus*	CT, FP	R
m	Hardhead	*Mylopharodon conocephalus*	CSC, SC	R
m	California wolverine	*Gulo gulo*	CT	MR, MW
m	Yellow-breasted chat	*Icteria virens*	CSC	VFR, MR
m	California gull	*Larus californicus*	CSC	L, NTFE, NSW
m	Northern harrier	*Circus cyaneus*	CSC	NTFE, NSW, G
m	Black-crowned night heron	*Nycticorax nycticorax*	SC	NTFE, VFR, MR
m	Snowy egret	*Egretta thula*	SC	NTFE, VFR, MR
m	Great egret	*Casmerodius albus*	SC	VFR, MR
m	Cooper's hawk	*Accipiter cooperii*	CSC	VFR, MR, VFW, MW
m	Double-crested cormorant	*Phalacrocorax auritus*	CSC	VFR, MR
m	Western spadefoot toad	*Scaphiopus hammondii*	CSC	NSW, G

Sacramento River Main Stem

Goal	Common Name	Scientific Name	Status
R	Central Valley steelhead	*Oncorhyncus mykiss*	FT
R	Central Valley spring-run Chinook salmon	*Oncorhyncus tshawytscha*	FT, CT
R	Sacramento River winter-run Chinook salmon	*Oncorhyncus tshawytscha*	FE, CE
R	Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	FT
R	Green sturgeon	*Acispenser medirostris*	FT, CSC
R	Delta smelt	*Hypomesus transpacificus*	FT, CT
R	Sacramento splittail	*Pogonichthys macrolepidotus*	SC, CSC
r	Bank swallow	*Riparia riparia*	CT
r	Swainson's hawk	*Buteo swainsoni*	CT
r	California yellow warbler	*Dendroica petechia brewsteri*	CSC
r	Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	CE, C
r	Northern California black walnut	*Juglans californica* var. *hindsii*	SC
m	Tricolored blackbird	*Agelaius tricolor*	CSC, SC
m	Hardhead	*Mylopharodon conocephalus*	CSC
m	Yellow-breasted chat	*Icteria virens*	CSC
m	Long-billed curlew	*Numenius americanus*	CSC
m	Western least bittern	*Ixobrychus exilis*	CSC
m	Black-crowned night heron	Nycticorax nycticorax	SC
m	Snowy egret	*Egretta thula*	SC
m	Great egret	*Casmerodius albus*	SC
m	White-tailed kite	*Elanus leucurus*	FP
m	Cooper's hawk	*Accipiter cooperii*	CSC
m	Double-crested cormorant	*Phalacrocorax auritus*	CSC
m	Western spadefoot toad	*Scaphiopus hammondii*	CSC

Sacramento-San Joaquin Delta

Goal	Common Name	Scientific Name	Status
R	Delta smelt	*Hypomesus transpacificus*	FT, CT
R	Sacramento splittail	*Pogonichthys macrolepidotus*	SC, CSC
R	Longfin smelt	*Spirinchus thaleichtys*	PT, CSC
R	Sacramento perch	*Archoplites interruptus*	CSC, SC
R	Central Valley steelhead	*Oncorhyncus mykiss*	FT
R	Central Valley spring-run Chinook salmon	*Oncorhyncus tshawytscha*	FT, CT
R	Sacramento River winter-run Chinook salmon	*Oncorhyncus tshawytscha*	FE, CE
R	Green sturgeon	*Acispenser medirostris*	FT, CSC

* CALFED actions are prohibited from causing direct mortality to species marked with " * "

Habitat
VFR = Valley Foothill/Riparian Habitat
MR = Montane Riparian Habitat
GR = Grassland
US = Upland Scrub
VFW = Valley/Foothill Woodland and Forest
MW = Montane Woodland
L = Lacustrine
R = Riverine
NTFE = Nontidal Freshwater Permanent Emergent Habitat

NSW = Natural Seasonal Wetland

Species Goals:
R = Recovery. Recover species' populations within the MSCS focus area to levels that ensure the species' long-term survival in nature.
r = Contribute to recovery. Implement some of the actions deemed necessary to recover species' populations within the MSCS focus area.
m = Maintain. Ensure that any adverse effects on the species that could be associated with implementation of CALFED actions will be fully offset through implementation of actions beneficial to the species.
Status:
Federal
FE = Listed as endangered under FESA.
FT = Listed as threatened under FESA.
PE = Proposed for listing as endangered under FESA.
PT = Proposed for listing as threatened under FESA.
C = Candidate for listing under FESA.
PR = Protected under the Bald and Golden Eagle Protection Act,

State
CE = Listed as endangered under CESA.
CT = Listed as threatened under CESA.
CCE = Candidate for listing as endangered under CESA.
CCT = Candidate for listing as threatened under CESA.
R = Listed as rare under California Native Plant Protection Act.
CSC = California species of special concern.
FP = Fully protected under California Fish and Game Code.
SB = Specified birds under California Fish and Game Code.

Other
1A = CNPS List 1A.
1B = CNPS List 1B.
2 = CNPS List 2.
3 = CNPS List 3.
SC = Other species of concern identified by CALFED.

Conservation Measures by Habitat Type Recommended by CALFED

Conservation Measures for Valley Riverine Aquatic Habitat

Affected MSCS species include: Bald eagle, osprey, bank swallow, California red-legged frog, western pond turtle, foothill yellow-legged frog, Central California Coast steelhead evolutionarily significant unit (ESU), Central Valley steelhead ESU, Central Valley steelhead ESU critical habitat, Sacramento River winter-run chinook salmon ESU, Sacramento River winter-run Chinook salmon ESU critical habitat, bank swallow, black tern, Sacramento splittail, Central Valley fall-/late-fall-run chinook salmon ESU, Central Valley spring-run chinook salmon ESU, Central Valley spring-run chinook salmon ESU critical habitat, hardhead, Sacramento perch, and green sturgeon.

1. Avoid or minimize implementing transfers of water from sources that support flows that are beneficial to maintaining populations of native aquatic species.

2. To the extent practicable, augment flows from other sources to maintain existing flow conditions.

3. Avoid or minimize disturbance to existing shaded riverine aquatic overhead cover.

4. Restore or enhance l-3 times the linear footage of affected shaded riverine aquatic overhead cover near where impacts are incurred.

5. To the extent practicable, include project design features that allow for onsite reestablishment and long-term maintenance of shaded riverine aquatic overhead cover following project construction.

6. Avoid or minimize implementing actions during the periods evaluated species are present and could be affected by the actions.

7. To the extent practicable, remove or exclude evaluated amphibian and reptile species from construction corridors before construction is initiated.

8. To the extent consistent with achieving CALFED objectives, avoid constructing storage reservoirs on tributaries that support spawning populations of anadromous fish.

9. Provide sufficient outflow from storage reservoirs to maintain existing aquatic habitat conditions downstream of new storage reservoirs.

10. To the extent consistent with achieving CALFED objectives, design storage facilities to allow passage of anadromous fish to and from spawning habitat located above reservoirs.

11. To the extent practicable, trap and relocate evaluated wildlife species that would be unlikely to escape from the inundation area of new storage reservoirs to suitable nearby habitat areas.

12. Manage recreational uses associated with storage reservoirs to reduce or avoid the likelihood for recreation related impacts on sensitive valley riverine aquatic habitat areas and associated species.

Conservation Measures for Montane Riverine Aquatic Habitat

Affected MSCS species include: Bald eagle, osprey, California red-legged frog, northwestern pond turtle, foothill yellow-legged frog, rough sculpin, and hardhead.

1. Avoid implementing transfers of water from sources that support flows that are beneficial to maintaining populations of native aquatic species.

2. To the extent practicable, augment flows from other sources to maintain existing flow conditions.

3. Avoid or minimize implementing actions during the periods evaluated species are present and could be affected by the actions.

4. To the extent consistent with achieving CALFED objectives, avoid constructing storage reservoirs on tributaries that support spawning populations of anadromous fish.

5. Provide sufficient outflow from storage reservoirs to maintain existing aquatic habitat conditions downstream of storage reservoirs.

6. To the extent practicable, design storage facilities to allow passage of anadromous fish to and from spawning habitat located above reservoirs.

7. To the extent practicable, trap and relocate evaluated wildlife species that would be unlikely to escape from the inundation area of new storage reservoirs to suitable nearby habitat.

8. Manage recreational uses at new storage reservoirs to reduce or avoid the likelihood for recreation-related impacts on sensitive montane riverine aquatic habitat and its associated species.

Conservation Measures for Lacustrine Habitat

Affected MSCS species include: American peregrine falcon, bald eagle, Aleutian Canada goose, California gull, osprey, California red-legged frog, and western pond turtle.

1. Avoid or minimize disturbance to existing high value habitat.

2. Avoid or minimize construction activities during the breeding period of evaluated species that are present in existing habitat that could be affected by the actions.

3. Avoid or minimize direct disturbance to populations and individuals of evaluated plant species.

4. Establish and protect additional populations of evaluated plant species in suitable nearby habitat before implementing construction activities that could affect existing populations or individuals.

5. Avoid or minimize implementing transfers of water from sources that support high value lacustrine habitats.

Conservation Measures for Nontidal Freshwater Permanent Emergent Habitat

Affected MSCS species include American peregrine falcon, Aleutian Canada goose, California gull, northern harrier, tricolored blackbird, long-billed curlew, western least bittern, black-crowned night heron (rookery), and snowy egret (rookery), California red-legged frog, western pond turtle, and Bellinger’s meadowfoam.

1. Avoid or minimize disturbance to existing habitat.

2. Before implementing actions that could result in the loss or degradation of habitat, restore or enhance l-3 acres of additional in-kind habitat for every acre of existing habitat affected by restoration near where impacts would occur.

3. Avoid or minimize construction activities during the breeding period of evaluated species that could be affected by these actions.

4. Avoid or minimize direct disturbance to populations and individuals of evaluated plant species.

5. Establish and protect additional populations of evaluated plant species in suitable nearby habitat before implementing construction activities that could affect existing populations or individuals.

6. Avoid or minimize implementing transfers of water from sources that support emergent wetland vegetation.

7. To the extent practicable, trap and relocate to suitable nearby habitat evaluated wildlife species that would be unlikely to escape from inundation of new or enlarged storage reservoirs.

8. Provide sufficient outflow from storage reservoirs to support the long-term maintenance of wetland vegetation downstream of storage reservoirs.

9. Minimize effects of construction-related runoff into nearby wetlands through use of siltation control barriers, detention basins, or other appropriate methods.

Conservation Measures for Valley Foothill/Riparian Habitat

Affected MSCS Species: greater western mastiff-bat, ringtail, bald eagle, little willow flycatcher, bank swallow, western yellow-billed cuckoo, white-tailed kite, golden eagle, Swainson's hawk, California yellow warbler, yellow-breasted chat, long-eared owl, Cooper's hawk, osprey, double-crested cormorant (rookery), black-crowned night heron (rookery), great blue heron (rookery), great egret (rookery), snowy egret (rookery), western pond turtle, foothill yellow-legged frog, Sacramento splittail, California red-legged frog, valley elderberry longhorn beetle, valley elderberry longhorn beetle critical habitat, Northern California black walnut (native stands), and silky cryptantha.

1. Avoid or minimize disturbance to existing habitat.

2. Restore or enhance 2-5 acres of additional in-kind habitat for every acre of affected habitat near where impacts are incurred before implementing actions that could result in the loss or degradation of habitat.

3. To the extent practicable, include project design features that allow for onsite reestablishment and long-term maintenance of riparian vegetation following project construction.

4. Avoid or minimize construction activities during the breeding period of evaluated species that could be affected by these actions.

5. Avoid or minimize direct disturbance to populations and individuals of evaluated plant species.

6. Establish and protect additional populations of evaluated plant species in suitable nearby habitat areas before implementing construction activities that could affect existing populations or individuals.

7. To the extent practicable, remove or exclude evaluated amphibian and reptile species from construction corridors before construction is initiated.

8. Avoid or minimize implementing transfers of water from sources that support riparian vegetation.

9. To the extent consistent with CALFED objectives, operate barriers in a manner that will not adversely affect the hydrology supporting riparian vegetation upstream of barriers.

10. Trap and relocate evaluated wildlife species that would be unlikely to escape from storage reservoir inundation areas to suitable nearby habitat areas.

11. Provide sufficient outflow from storage reservoirs sufficient to support the long-term maintenance of existing riparian vegetation downstream of storage reservoirs.

12. Manage recreational uses at new storage reservoirs to reduce or avoid the likelihood for recreation-related impacts on sensitive plant populations and wildlife use areas.

Conservation Measures for Montane Riparian Habitat

Affected MSCS species include: California wolverine, ringtail, greater western mastiff-bat, bald eagle, little willow flycatcher, California yellow warbler, yellow-breasted chat, long-eared owl, Cooper’s hawk, osprey, double-crested cormorant (rookery), black-crowned night heron (rookery), great blue heron (rookery), great egret (rookery), snowy egret (rookery), double-crested cormorant, foothill yellow-legged frog, California red-legged frog, valley elderberry longhorn beetle, valley elderberry longhorn beetle critical habitat, and silky cryptantha.

1. Avoid or minimize transfers of water from sources that support riparian vegetation.

2. Restore or enhance 2-5 acres of additional in-kind habitat for every acre of affected habitat near where impacts would occur before implementing actions that could result in the loss or degradation of habitat.

3. Avoid or minimize disturbance to existing habitat.

4. Avoid or minimize construction activities during the breeding period of evaluated species that could be affected by these actions.

5. Avoid or minimize direct disturbance to populations and individuals of evaluated plant species.

6. Establish and protect additional populations of evaluated plant species in suitable nearby habitat before construction activities are implemented that could affect existing populations or individuals.

7. Provide outflow from storage reservoirs sufficient to support the long-term maintenance of existing downstream riparian vegetation.

8. To the extent practicable, trap and relocate evaluated species that would be unlikely to escape from the inundation area of storage reservoirs to suitable nearby habitat.

9. Manage recreational uses at new storage reservoirs to reduce or avoid the likelihood for recreation-related impacts on sensitive plant populations and wildlife use areas.

Conservation Measures for Grassland Habitat

Affected MSCS species include: greater western mastiff-bat, tricolored blackbird, long-billed curlew, northern harrier, California red-legged frog, western spadefoot toad, white-tailed kite, golden eagle, Swainson's hawk, and silky cryptantha.

1. Before implementing actions that could result in the loss or degradation of evaluated species, restore or enhance l-3 acres of grassland within the current range of affected species, and near where impacts would occur.

2. Avoid or minimize construction activities during the breeding period of evaluated species that could be affected by these actions.

3. Avoid or minimize direct disturbance to populations and individuals of evaluated plant species.

4. Establish and protect additional populations of evaluated plant species in suitable nearby habitat before implementing construction activities that could affect existing populations or individuals.

5. Manage recreational uses to avoid or reduce potential adverse effects on near sensitive plant populations and wildlife use areas.

Conservation Measures for Upland Scrub Habitat (i.e., Mixed Chaparral)

Affected MSCS species include: Ringtail, greater western mastiff-bat, golden eagle, and Swainson's hawk.

1. Avoid or minimize construction activities during the breeding period of evaluated existing habitat that could be affected by these actions.

2. Avoid or minimize direct disturbance to populations and individuals of evaluated plant species.

3. Establish and protect additional populations of evaluated plant species in suitable nearby habitat before implementing construction activities that could affect existing populations or individuals.

4. Before implementing actions that could result in the loss or degradation of evaluated species, restore or enhance 2-5 acres additional in-kind habitat for every acre of existing habitat occupied by evaluated species affected by the actions within the current range of affected species and near where impacts occur.

5. Manage recreational uses associated with new or enlarged reservoirs to reduce or avoid the likelihood for recreation-related impacts on sensitive plant populations and wildlife use areas.

Conservation Measures for Valley/Foothill Woodland and Forest Habitat (i.e., Blue Oak-Grey pine and Blue Oak Woodland)

Affected MSCS species include: Greater western mastiff-bat, ringtail, golden eagle, Swainson’s hawk, long-eared owl, Cooper’s hawk, osprey, Shasta salamander, Bellinger’s meadowfoam, Shasta clarkia, silky cryptantha, Shasta snow-wreath, and thread-leaved beardtongue.

1. Avoid or minimize disturbance to existing habitat.

2. Restore or enhance 2-5 acres of additional in-kind habitat for every acre of existing habitat adversely affected by the actions near where impacts would be incurred.

3. Avoid or minimize construction activities during the breeding period of evaluated species that could be affected by the actions.

4. Avoid or minimize direct disturbance to populations and individuals of evaluated plant species.

5. Establish and protect additional populations of evaluated plant species in suitable nearby habitat before implementing construction activities that could affect existing populations or individuals.

6. Manage recreational uses to reduce or avoid the likelihood for recreation-related impacts on sensitive plant populations and wildlife use areas in the vicinity of new or enlarged storage reservoirs.

Conservation Measures for Montane Woodland and Forest Habitat (i.e., Montane Hardwood – Conifer, Montane Hardwood, Ponderosa Pine, and Sierran Mixed Conifer)

Affected MSCS species include: Ringtail, greater western mastiff-bat, California wolverine, northern spotted owl, northern spotted owl critical habitat, bald eagle, Cooper’s hawk, osprey, Shasta salamander, Shasta sideband, silky cryptantha, Shasta snow-wreath, and thread-leaved beardtongue.

1. Restore or enhance 2-5 acres of additional in-kind habitat for every acre of existing habitat affected by the actions near where impacts would occur.

2. Avoid or minimize construction activities during the breeding period of evaluated species that are present in existing habitat that could be affected by the actions.

3. Avoid or minimize direct disturbance to populations and individuals of evaluated plant species.

4. Establish and protect additional populations of evaluated plant species in suitable nearby habitat before implementing construction activities that could affect existing populations or individuals.

5. Manage recreational uses to reduce or avoid the likelihood for recreation-related impacts on sensitive plant populations and wildlife use areas in the vicinity of new or enlarged reservoirs.

<u>Species–Specific Conservation Measures for Multi-Species Conservation Strategy Species</u>

The following conservation measures are identified in the Multi-Species Conservation Strategy, Final Programmatic EIS/EIR Technical Appendix July 2000 (Appendix E, Multi-Species Conservation Strategy Prescriptions and Conservation Measures for Evaluated Species) (CALFED Bay-Delta Program 2000)

Bank swallow (*Riparia riparia*)

Allow reaches of the Sacramento River and its tributaries that are unconfined by flood control structures (*i.e.*, bank revetment and levees) to continue to meander freely, thereby creating suitable bank nesting substrates through the process of bank erosion.

<u>Conservation Measures that Add Detail to CALFED Actions</u>

1. Coordinate protection and restoration of channel meander belts and existing bank swallow colonies with other federal and State programs (*e.g.*, the Senate Bill [SB] 1086 program and U.S. Army Corps of Engineer’s Sacramento and San Joaquin Basin Comprehensive Study Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historical habitat use areas. Coordination would avoid conflicts among management objectives and identify opportunities for achieving multiple management objectives.

2. Proposed ERP actions designed to protect or restore stream meander belts should initially be implemented along reaches of the Sacramento River and its tributaries that support nesting colonies or nesting habitat.

3. Monitor to determine the response of bank swallows to restoration of stream meander belts and riparian habitat.

4. Coordinate with the U.S. Bureau of Reclamation and California Department of Water Resources (DWR) to phase spring-summer reservoir releases in a manner that would reduce the potential for adverse effects on nesting colonies that could result from large, pulsed releases.

Conservation Measures to Avoid, Minimize, and Compensate for Adverse Effects

1. Before implementing actions that could result in take or the loss or degradation of occupied habitat, conduct surveys in suitable habitat within portions of the species' range that CALFED actions could affect to determine the presence and distribution of the species.

2. Avoid or minimize actions that could adversely affect known colonies or unoccupied river reaches with eroding banks composed of soils that would provide suitable nesting substrate.

3. Avoid actions near active colonies from April through August.

4. To the extent practicable, avoid actions that would create suitable, but temporary, nesting habitat that could create population sinks by attracting bank swallows, or implement additional actions to render such habitat unattractive to bank swallows.

California yellow warbler (*Dendroicapetechia brewsteri*) and Little willow flycatcher (*Empidonax traillii brewsteri*)

Maintain and enhance suitable riparian corridor migration habitats and restore suitable breeding habitat within the historical breeding range of these species in the Central Valley.

Conservation Measures that Add Detail to CALFED Actions

1. Coordinate protection and restoration of riparian habitat with other Federal, State, and nonprofit programs (*e.g.*, the Riparian Habitat Joint Venture, the SB1086 program and U.S. Army Corps of Engineer's Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historical habitat use areas. Coordination would avoid conflicts among management objectives and identify opportunities for achieving multiple management objectives.

2. To the extent consistent with CALFED objectives, protect existing suitable riparian habitat corridors from future changes in land use or other activities that could result in the loss or degradation of habitat.

3. A portion of restored riparian habitat should be designed to include riparian scrub communities.

4. To the extent practicable, restore riparian habitats in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.

Conservation Measures to Avoid, Minimize, and Compensate for Adverse Effects

1. Fully mitigate for impacts on existing nesting habitat that may be associated with Watershed Program or other CALFED actions.

2. Before implementing actions that could result in take or the loss or degradation of occupied habitat, conduct surveys in suitable and potentially occupied nesting habitat within portions of the species' range that CALFED actions could affect to determine the presence and distribution of the species.

Swainson's Hawk (*Buteo swansonii*)

Protect, enhance, and increase habitat sufficient to support a viable breeding population. The interim prescription is to increase the current estimated population of 1,000 breeding pairs in the Central Valley to 2,000 breeding pairs. This prescription will be modified based on results of a population viability analysis being conducted by the California Department of Fish and Game (CDFG).

Conservation Measures that Add Detail to CALFED Actions

1. Proposed ERP actions designed to restore valley/foothill riparian habitat should initially be implemented in the Delta.

2. To the extent practicable, design restored seasonal wetlands in occupied habitat to provide overwinter refuge for rodents to provide source prey populations during spring and summer.

3. To the extent consistent with CALFED objectives, enhance at least 10% of agricultural lands to be enhanced under the ERP in the Delta, Sacramento River, and San Joaquin River Regions to increase forage abundance and availability within 10 miles of occupied habitat.

4. To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase their current population levels.

5. To the extent practicable, manage restored or enhanced habitats under the ERP to maintain desirable rodent populations and minimize impacts associated with rodent control.

Conservation Measures to Avoid, Minimize, and Compensate for Adverse Effects

1. Before implementing actions that could result in take or the loss or degradation of occupied habitat, conduct surveys in suitable habitat within portions of the species' range

that CALFED actions could affect to determine the presence and distribution of the species.

2. Avoid or minimize actions near locations that support high densities of nesting pairs that could adversely affect high value foraging and nesting habitat.

3. Avoid or minimize actions within 5 miles of active nest sites that could result in disturbance during the breeding period (April-September).

4. To the extent consistent with CALFED objectives, adhere to DFG Region II mitigation guidelines for avoiding or minimizing impacts of actions on the Swainson's hawk.

5. To the extent practicable, implement ERP restoration or enhancement of suitable Swainson's hawk habitats (*i.e.*, riparian forest and woodland, grassland, and upland croplands) concurrent with ERP actions that would convert suitable existing habitat to unsuitable habitat (*e.g.*, tidal habitats).

Western Yellow-Billed cuckoo (Coccyzus americanus occidentalis)

Protect existing suitable riparian forest habitat within the species' historical range, and increase the area of suitable riparian forest habitat sufficiently to allow the natural expansion of the Sacramento Valley population.

<u>Conservation Measures that Add Detail to CALFED Actions</u>

1. Coordinate protection and restoration of riparian habitat with other Federal, State, and nonprofit programs (*e.g*., the Riparian Habitat Joint Venture, the SB1086 program, and U.S. Army Corps of Engineer's Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historical habitat use areas. Coordination would avoid conflicts among management objectives and identify opportunities for achieving multiple management objectives.

2. Initially direct ERP actions to restore suitable valley/foothill riparian forest and woodland along at least 10 contiguous miles of channels in the Delta to create a riparian forest corridor at least 200 meters wide.

3. Restore contiguous blocks of suitable valley/foothill riparian forest and woodland at least 200 meters wide and 500 acres in size along reaches of the Sacramento River adjacent to occupied habitat (Red Bluff to Colusa).

<u>Conservation Measures to Avoid, Minimize, and Compensate for Adverse Effects</u>

1. Before implementing actions that could result in take or the loss or degradation of occupied habitat, conduct surveys in suitable habitat within portions of the species' range that CALFED actions could affect to determine the presence and distribution of the species.

2. Avoid or minimize actions that could degrade or result in the loss of suitable nesting habitat within the species current and historical range.

3. Avoid CALFED actions near active nest sites that could result in disturbance during the breeding period (May-August).

Shasta snow-wreath (*Neviusia cliftonii*), Shasta clarkia (*Clarkia borealis* ssp. *arida*), and Bellinger's meadowfoam (*Limnanthes floccosa* ssp. *bellingeriana*) propagation?

1. Before implementing actions that could result in the loss or degradation of occupied habitat, conduct surveys in suitable habitat that could be affected by CALFED actions to determine whether species are present.

2. Avoid CALFED actions that could result in harm or mortality to individuals or to the viability of populations of these species.

Greater Western Mastiff-Bat (*Eumops perotis californicus*)

1. Before implementing actions that could result in the loss or degradation of roost habitat, conduct surveys in suitable habitat within the range of the species that could be affected by CALFED actions to locate traditional greater western mastiff-bat roosts.

2. Avoid CALFED actions that could result in the substantial loss or degradation of roosts that support core species populations essential to maintaining the viability and distribution of the species.

3. To the extent consistent with CALFED objectives, manage lands purchased or acquired under conservation easements that support roost sites to protect roost sites from disturbances that could cause their abandonment and from management actions that could result in the loss or degradation of roosting structures.

Ringtail (Bassariscus astutus)

1. Where CALFED actions would adversely affect occupied habitat, (a) acquire, protect, and manage 2-5 acres of existing occupied habitat for every acre within the same area of occupied habitat affected by CALFED actions or (b) enhance or restore 2-5 acres of suitable habitat near affected areas for every acre of occupied habitat affected.

2. To the extent consistent with Ecosystem Restoration Program (ERP) objectives, restore valley/foothill riparian habitats adjacent to occupied habitats to create a buffer of natural habitat. This buffer would protect populations from adverse effects that could be associated with future changes in land use on nearby lands and provide suitable habitat for the natural expansion of populations.

Long-eared owl (*Asio otus*)

1. Before implementing CALFED actions that could result in the loss or degradation of traditional nesting territories or disturbance to nest sites, conduct surveys in suitable

nesting habitat within portions of the species' breeding range that could be affected by CALFED actions to locate active nest sites.

2. Avoid or minimize disturbances to nesting pairs that could be associated with implementing CALFED actions within 0.25 mile of active nest sites during the nesting period (March-July).

3. Restore or enhance 2-5 acres of suitable nesting habitat for each acre of occupied nesting habitat that is converted to unsuitable nesting habitat as a result of CALFED actions.

4. To the extent consistent with ERP objectives, enhance and restore natural and agricultural habitats adjacent to occupied nesting habitats to create buffer habitat. This buffer would protect nesting pairs from adverse effects that could be associated with future changes in land use on nearby lands and provide foraging and nesting habitat suitable for the natural expansion of populations.

5. To the extent consistent with ERP objectives, manage restored or enhanced habitats to maintain desirable rodent populations and minimize impacts associated with rodent control.

Northern spotted owl (Strix occidentalis caurina)

1. Avoid construction- and recreation-related disturbances that could be associated with implementing CALFED actions within 0.5 mile of active nest sites during the nesting period (March-June).

2. Avoid or minimize CALFED actions that could result in the loss of traditional nesting sites or degradation of natural habitat within 0.5 mile of traditional nest sites.

3. To the extent consistent with CALFED actions, design and implement CALFED Watershed Program actions to maintain, enhance, or restore suitable habitat within the species' current range.

Osprey (*Pandion haliaetus*)

1. Before implementing CALFED actions that could result in the loss nesting structures or disturbance to nesting pairs, conduct surveys to determine the presence and distribution of active nest sites along the Sacramento River and other major tributaries to the Bay-Delta.

2. Avoid or minimize disturbances that could be associated with implementing CALFED actions near active nest sites during the nesting period (March-August).

3. Avoid or minimize CALFED actions that could result in the degradation or loss of nesting structures.

Yellow-breasted Chat (*Icteria virens*)

1. Before implementing CALFED actions that could result in the loss or degradation of occupied nesting habitat or disturbance to nesting pairs, conduct surveys in suitable nesting habitat within the portions of the species' breeding range that could be affected by CALFED actions to locate nesting pairs.

2. Avoid or minimize disturbances to nesting pairs that could be associated with implementing CALFED actions during the nesting period (May-August).

3. Restore or enhance 2-5 acres of suitable nesting habitat near affected areas for each acre of occupied nesting habitat that is converted to unsuitable nesting habitat as a result of CALFED actions.

4. To the extent consistent with ERR objectives, design and manage riparian habitat restorations and enhancements to provide suitable nesting and foraging habitat conditions.

Northwestern Pond Turtle (*Clemmys marmorata marmorata*)

1. Where CALFED actions would adversely affect occupied habitat, (a) acquire, protect, and manage l-5 acres of existing occupied habitat for every acre within the same area of occupied habitat affected by CALFED actions or (b) enhance or restore l-5 acres of suitable habitat near affected areas for every acre of occupied habitat affected.

2. To the extent practicable, capture individuals from habitat that would be affected by CALFED actions, and relocate them to nearby suitable existing, restored, or enhanced habitat.

Foothill Yellow-Legged Frog (*Rana boylii*), California Red-Legged Frog (*Rana aurora draytonii*), and Western Spadefoot Toad (*Scaphiopus hammondii*)

1. Avoid CALFED actions that could adversely affect the connectivity of habitat corridors among existing metapopulations.

2. Where CALFED actions would adversely affect occupied habitat, (a) acquire, protect, and manage 1-3 acres of existing occupied habitat for every acre of occupied habitat affected by CALFED actions or (b) enhance or restore l-3 acres of suitable habitat near affected areas for every acre of occupied habitat affected.

3. To the extent practicable, remove or exclude individuals from the affected area to avoid construction-related mortality of individuals or, if habitat will be permanently lost as a result of actions, capture individuals from the affected area and relocate to nearby suitable existing, restored, or enhanced habitat that does not support non-native predator populations.

4. Avoid or minimize CALFED actions that could increase or attract non-native predator populations to occupied habitat.

5. To the extent consistent with ERP objectives, enhance or restore suitable habitats near occupied habitat.

Shasta Salamander (*Hydromantes shastae*)

1. Where CALFED actions would adversely affect occupied habitat, (a) acquire, protect, and manage 2-5 acres of existing occupied habitat for every acre of occupied habitat affected by CALFED actions or (b) enhance or restore 2-5 acres of suitable habitat near affected areas for every acre of occupied habitat affected.

2. To the extent practicable, remove or exclude individuals from the affected area to avoid construction-related mortality of individuals or, if habitat will be permanently lost as a result of actions, capture individuals from the affected area and relocate to nearby suitable existing, restored, or enhanced habitat that does not support non-native predator populations.

Shasta Sideband (Monadenia troglodytes)

1. Where CALFED actions would adversely affect occupied habitat, (a) acquire, protect, and manage 2-5 acres of existing occupied habitat for every acre within the same area of occupied habitat affected by CALFED actions or (b) enhance or restore 2-5 acres of suitable habitat near affected areas for every acre of occupied habitat affected.

2. To the extent practicable, remove or exclude individuals from the affected area to avoid construction-related mortality of individuals or, if habitat will be permanently lost as a result of actions, capture individuals from the affected area and relocate to nearby suitable existing, restored, or enhanced habitat.

Silky Cryptantha (*Cryptantha crinita*)

1. Avoid or minimize CALFED actions that could result in harm or mortality to individuals or to the viability of these species' populations or that could result in the degradation or loss of high-quality species-occupied natural habitat.

2. If occupied habitat is lost or degraded as a result of CALFED actions, preserve (preferably by acquisition) 6 acres of high-quality occupied habitat and preserve 1 acre of suitable unoccupied habitat for every acre of habitat affected by CALFED.

3. Develop a seedbank from all populations affected by implementation of CALFED actions, and use the collected seed for inoculating unoccupied suitable habitat.

4. To the extent consistent with ERP objectives, enhance or restore suitable habitats to benefit these species in occupied habitat.

Thread-Leaved Beardtongue (*Penstemon filiformis*)

1. Before implementing actions that could result in the loss or degradation of occupied habitat, conduct surveys in suitable habitat that could be affected by CALFED actions to determine whether species are present.

2. Avoid CALFED actions that could result in harm or mortality to individuals or to the viability of populations of these species.

3. Monitor all sites occupied by these species that are managed under CALFED, especially following management activities; through adaptive management, modify activities as needed to maintain or increase current population levels.

Great Blue Heron (*Ardea herodias*) Black-Crowned Night Heron (rookery) (*Nycticorax nycticorax*), Snowy Egret (rookery) (*Egretta thula*), and Great Egret (rookery) (*Casmerodius albus*)

1. Before implementing CALFED actions that could result in the loss or degradation of traditional nesting habitat or disturbance to nesting colonies, conduct surveys in suitable nesting habitat within portions of the species' breeding range that could be affected by CALFED actions to locate nesting colonies.

2. Avoid or minimize disturbances to nesting colonies that could be associated with implementing CALFED actions within 0.25 mile of active nesting colonies during the nesting period (February-August).

3. Avoid or minimize CALFED actions that could result in the degradation or loss of traditional nesting habitat.

4. Restore or enhance l-5 acres of suitable valley/foothill riparian or emergent wetland nesting habitat near affected areas for each acre of occupied nesting habitat that is converted to unsuitable nesting habitat as a result of CALFED actions.

5. To the extent consistent with ERP objectives, design and manage valley/foothill riparian, wetland, and agricultural habitat restorations and enhancements to provide suitable nesting and foraging habitat conditions.

6. To the extent consistent with ERP objectives, restore habitats adjacent to nesting colonies to create a buffer of natural habitat. This buffer would protect colonies from adverse effects that could be associated with future changes in land use on nearby lands and provide foraging and nesting habitat suitable for the natural expansion of populations.

Tricolored Blackbird (*Agelaius tricolor*)

1. Before implementing CALFED actions that could result in the loss or degradation of traditional nesting habitat or disturbance to nesting colonies, conduct surveys in suitable nesting habitat within portions of the species' range that could be affected by CALFED actions to locate nesting colonies.

2. Avoid or minimize disturbances to nesting colonies that could be associated with implementing CALFED actions within 0.25 mile of active nesting colonies during the nesting period (mid-April-July).

3. To the extent consistent with ERP objectives, design and manage wetland and agricultural habitat restorations and enhancements to provide suitable nesting and foraging habitat conditions.

4. To the extent consistent with ERP objectives, enhance and restore natural and agricultural habitats adjacent to known nesting colonies to create a buffer zone of natural habitat. This buffer zone would protect colonies from adverse effects that could be associated with future changes in land use on nearby lands and provide foraging and nesting habitat suitable for the natural expansion of populations.

California Gull (*Larus californicus*)

1. Avoid or minimize disturbances to nesting colonies that could be associated with implementing CALFED actions within 0.25 mile of active nesting colonies during the nesting period (mid-April through mid-August).

2. Avoid or minimize CALFED actions that could adversely affect the nesting success or size of existing breeding colonies.

Northern Harrier (*Circus cyaneus*)

1. Restore or enhance l-2 acres of suitable wetland or grassland nesting habitat for each area of occupied nesting habitat that is converted to unsuitable nesting habitat as a result of CALFED actions.

2. To the extent consistent with ERP objectives, design and manage wetland, grassland, and agricultural land habitat restorations and enhancements to provide suitable nesting and foraging habitat conditions.

3. To the extent consistent with ERP objectives, restore wetland and perennial grassland habitats adjacent to occupied nesting habitats to create a buffer zone of natural habitat. This buffer zone would protect nesting pairs from adverse effects that could be associated with future changes in land use on nearby lands and provide suitable foraging habitat and nesting habitat suitable for the natural expansion of populations.

4. To the extent consistent with ERP objectives, manage enhanced agricultural lands to maintain or increase prey populations.

5. Avoid or minimize disturbances that could be associated with implementing CALFED actions near active nest sites during the nesting period (April-August).

Long-Billed Curlew (*Numenius americanus*)

1. Restore or enhance l-2 acres of suitable mudflat, seasonal wetland, grassland, upland cropland, or seasonally flooded agricultural foraging habitat for each acre of traditional foraging habitat that is converted to unsuitable foraging habitat as a result of CALFED actions.

2. To the extent consistent with ERP objectives, design and manage aquatic, wetland, grassland, and agriculture habitat restorations and enhancements to provide suitable foraging habitat.

Western Least Bittern (*Ixobrychus exilis*)

1. Avoid or minimize CALFED actions that could result in the degradation or loss of occupied nesting habitat.

2. Restore or enhance l-2 acres of suitable nesting wetland or grassland habitat for each acre of occupied nesting habitat that is converted to unsuitable nesting habitat as a result of CALFED actions.

3. To the extent consistent with ERP objectives, design and manage wetland habitat restorations and enhancements to provide suitable nesting and foraging habitat conditions.

4. To the extent consistent with ERP objectives, restore wetland habitats adjacent to occupied nesting habitats to create a buffer zone of natural habitat. This buffer zone would protect nesting pairs from adverse effects that could be associated with future changes in land use on nearby lands and provide foraging and nesting habitat suitable for the natural expansion of populations.

5. Avoid or minimize disturbances that could be associated with implementing CALFED actions near active nest sites during the nesting period (April-August).

Golden Eagle (*Aquilu chrysaetos*)

1. Enhance or restore 1-5 acres of suitable foraging habitat to replace every acre of traditional foraging habitat permanently lost or degraded as a result of CALFED actions.

2. Avoid or minimize construction- and recreation-related disturbances that could be associated with implementing CALFED actions within 0.5 mile of active nest sites during the nesting period (mid-January-August).

3. Avoid or minimize CALFED actions that could result in the degradation or loss of nesting structures.

4. To the extent consistent with ERP objectives, manage restored or enhanced habitats under the ERR to maintain desirable rodent populations and minimize impacts associated with rodent control.

5. To the extent consistent with ERR objectives, restore perennial grasslands adjacent to traditional nest sites to provide foraging and nesting habitat suitable for the natural expansion of populations.

White-Tailed Kite (*Elanus leucurus*)

1. Before implementing CALFED actions that could result in the loss or degradation of occupied nesting habitat or disturbance to nesting pairs, conduct surveys in suitable nesting habitat within the breeding range of the white-tailed kite to locate active nest sites.

2. Avoid or minimize disturbances to nesting pairs that could be associated with implementing CALFED actions within 0.25 mile of active nest sites during the nesting period (February-September).

3. Avoid or minimize CALFED actions that could result in the loss of traditional nesting trees.

4. Restore or enhance 2-5 acres of suitable nesting habitat near affected areas for each acre of occupied nesting habitat that is converted to unsuitable nesting habitat as a result of CALFED actions. Restored or enhanced compensation habitat should be located in areas that support nesting pairs near valley oak woodlands.

5. To the extent consistent with ERP objectives, enhance and restore natural habitats and agricultural habitats adjacent to occupied nesting habitats to create a buffer zone of natural habitat. This buffer zone would protect nesting pairs from adverse effects that could be associated with future changes in land use on nearby lands and provide foraging and nesting habitat suitable for the natural expansion of populations.

6. To the extent consistent with ERP objectives, manage restored or enhanced habitats under the ERR to maintain desirable rodent populations and minimize impacts associated with rodent control.

Cooper's Hawk (*Accipiter cooperii*)

1. Before implementing CALFED actions that could result in the loss or degradation of traditional nesting territories or disturbance to nest sites, conduct surveys in suitable nesting habitat within portions of the species' breeding range that could be affected by CALFED actions to locate active nest sites.

2. Avoid or minimize disturbances to nesting pairs that could be associated with implementing CALFED actions within 0.25 mile of active nest sites during the nesting period (March-August).

3. Avoid or minimize CALFED actions that could result in the loss of traditional nesting trees.

4. Avoid or minimize CALFED actions that could result in the substantial loss or degradation of suitable foraging and nesting habitat in areas that support core nesting populations.

5. Restore or enhance 2-5 acres of suitable nesting habitat near the affected area for each acre of occupied nesting habitat that is converted to unsuitable nesting habitat as a result of CALFED actions.

6. To the extent consistent with ERP objectives, restore valley/foothill riparian habitats adjacent to occupied nesting habitats to create a buffer of natural habitat.

7. This buffer would protect nesting pairs from adverse effects that could be associated with future changes in land use on nearby lands and provide foraging and nesting habitat suitable for the natural expansion of populations.

Double-Crested Cormorant (rookery) (*Phalacrocorax auritus*)

1. Before implementing CALFED actions that could result in the loss or degradation of traditional nesting habitat or disturbance to nesting colonies, conduct surveys in suitable nesting habitat within portions of the species' breeding range that could be affected by CALFED actions to locate nesting colonies.

2. Avoid or minimize disturbances to nesting colonies that could be associated with implementing CALFED actions within 0.25 mile of active nesting colonies during the nesting period (February-August).

3. Avoid or minimize CALFED actions that could result in the degradation or loss of nesting structures.

4. To the extent consistent with CALFED objectives, manage existing reservoirs that support breeding populations, and design and manage new storage reservoirs to provide suitable nesting and foraging habitat conditions.

Sacramento Splittail (*Pogonichthys macrolepidotus*):

Species recovery objectives will be achieved when two of the following three criteria are met in at least 4 of every 5 years for a 15 year period: (1) the fall midwater trawl survey numbers must be 19 or greater for 7 of 15 years, (2) the Suisun Marsh catch per trawl must be 3.8 or greater and the catch of young-of-year must exceed 3.1 per trawl for 3 of 15 years, and (3) Bay Study otter trawls must be 18 or greater and catch of young-of-year must exceed 14 for 3 out of 15 years.

<u>Conservation measures that add detail to CALFED actions</u>

1. Coordinate protection, enhancement, and restoration of occupied and historical Sacramento splittail habitats with other federal, State, and regional programs (e.g., the San Francisco Bay Ecosystem Goals Project, the Anadromous Fish Restoration Program, USFWS recovery plans, the SB1086 program and USACE's Sacramento and San Joaquin Basin Comprehensive Study) that could affect management of current and historical

habitat use areas. Coordination would avoid conflicts among management objectives and identify opportunities for achieving multiple management objectives.

2. To the extent consistent with CALFED objectives, remove diversion dams that block splittail access to lower floodplain river spawning areas.

3. Minimize changes in the timing and volume of freshwater flows in the rivers to the Bay-Delta.

4. To the extent consistent with CALFED objectives, direct ERP actions toward setting back levees in the south Delta to increase shallow-water habitat.

5. To the extent consistent with CALFED objectives, reduce the extent of reversed flows in the lower San Joaquin and Delta from February through June.

6. Reduce the loss of splittail at south Delta pumping plants from predation and salvage handling and transport.

7. Reduce the loss of young splittail to entrainment into south-Delta pumping plants.

8. To the extent practicable, reduce the loss of splittail at 1,800 unscreened diversions in the Delta.

9. Reduce losses of adult splittail spawners during their upstream migrations to recreational fishery harvest.

10. To the extent consistent with CALFED objectives, improve Delta water quality, particularly in dry years when pesticide levels and total dissolved solids are high.

11. To the extent consistent with CALFED objectives, reduce the concentration of pollutants in the Colusa Basin drain and other agricultural drains into the Bay-Delta and its watershed.

12. Modify operation of the DCC to minimize the potential to increase exposure of splittail population in the Delta to the south-Delta pumping plants.

13. Modify operation of the barrier at the Head of Old River to minimize the potential for drawing splittail toward the south-Delta pumping plants.

14. To the extent practicable, design and construct overflow basins from existing leveed lands in stages using construction design and operating schemes and procedures developed through pilot studies and project experience. The purpose of this action is to minimize the potential for stranding splittail as waters recede from overflow areas.

15. Design and construct a new intake screen system at the entrance to Clifton Court Forebay that minimizes potential involvement of splittail. Connect intakes of Tracy Pumping Plant to Clifton Court Forebay.

16. Consistent with CALFED objectives, design modifications to south-Delta channels to improve circulation and transport of north-of-Delta water to the south-Delta pumping plants. This action would ensure that habitat supports splittail and that transport of splittail to the south-Delta pumping plants is not increased.

17. To the extent practicable, design seasonal wetlands that have hydrological connectivity with occupied channels to reduce the likelihood of stranding and to provide the structural conditions necessary for spawning.

18. To the extent consistent with CALFED objectives, protect spawning areas by providing suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (e.g., submerged tree roots and branches, and above-water and submersed vegetation).

19. Avoid or minimize adverse effects on rearing habitat of physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruption (e.g., water diversions, in-channel barriers, or tidal gates).

20. To the extent consistent with CALFED objectives, maintain a low salinity zone in historically occupied habitat of the Bay and Delta from February 1 to August 31.

21. To the extent consistent with CALFED objectives, provide unrestricted access of adults to spawning habitat from December to July by maintaining adequate flow and water quality, and minimizing disturbance and flow disruption.

22. Expand IEP monitoring efforts in the south Delta for Sacramento splittail.

23. To the extent consistent with CALFED objectives, initiate implementation of the USFWS's "Rainbow Report" or similar documentation to provide increased water quality in the south Delta and eliminate or reduce the need for installation of barriers.

24. To the extent consistent with CALFED objectives, reduce the effects on splittail from changes in reservoir operations and ramping rates for flood control.

25. To the extent consistent with CALFED objectives, reduce the loss of freshwater and low-salinity splittail habitat in the Bay-Delta as a result of reductions in Delta inflow and outflow.

26. To the extent consistent with CALFED objectives, increase the frequency of flood bypass flooding in non-wet years to improve splittail spawning and early rearing habitat.

27. To the extent consistent with CALFED objectives, ensure that the Yolo and Sutter Bypasses are flooded during the spawning season at least once every 5 years.

28. To the extent consistent with CALFED objectives, improve the frequency, duration, and extent of bypass flooding in all years.

29. Develop a water management plan to allocate multiyear water supply in reservoirs to protect drought-year supplies and the source of winter-spring Delta inflow and outflow needed to sustain splittail and their habitats.

Conservation Measures to Avoid, Minimize, and Compensate for Adverse Effects

1. Consistent with CALFED objectives, limit dredging, diking, and filling of occupied shallow-water habitats.

2. Identify and pursue opportunities to provide operational flexibility of the CVP and SWP to eliminate or reduce the need for installation of barriers in the south Delta.

3. Avoid or minimize the use of hard structures (*i.e.*, riprap) to stabilize banks.

4. Consistent with CALFED objectives, construct and operate barriers in the Delta to minimize the threat to splittail from enhancing transport of water to south-Delta pumping plants.

5. From April through June, avoid increasing the Delta export rate above the currently permitted instantaneous diversion capacity, as described in USACE Public Notice No. 5820A Amended.

6. Consistent with CALFED objectives, conduct water transfers at times of the year that would not increase exposure of splittail to south-Delta pumping plants.

7. Implement applicable conservation measures to avoid, minimize, and compensate for impacts on Sacramento splittail listed in MSCS Attachment D, “Summary of Potential Beneficial and Adverse Program Effects and Conservation Measures”, Table D-20, “Estuarine Fish Group: Summary of Potential Beneficial and Adverse CALFED Effects and Conservation Measures”.

Northern California Black Walnut (*Juglans californica* var. *hindsii*) (native stands):

Protect and maintain the remaining stands, and establish 5-10 naturally regenerating black walnut stands within its historical range.

Conservation measures that add detail to CALFED actions

1. Protect, manage, and maintain existing native stands in conjunction with restoration of riparian habitats.

Conservation Measures to Avoid, Minimize, and Compensate for Adverse Effects

1. Before implementing actions that could result in take or the loss or degradation of occupied habitat, conduct surveys in suitable habitat within portions of the species’ range that CALFED actions could affect to determine the presence and distribution of the species.

2. Avoid or minimize CALFED actions that could result in mortality or the loss or degradation of habitat occupied by the species.

APPENDIX E

SPECIAL-STATUS SPECIES IN THE SHASTA LAKE WATER RESOURCES INVESTIGATION

Definition of Special-status Species

Special-status species are plants and wildlife that are (1) designated as rare, threatened, or endangered by the State or Federal governments (Federal and State Endangered Species Acts [ESA and CESA, respectively]; (2) are proposed for rare, threatened, or endangered status; (3) are State or Federal candidate species; (4) are identified by the California Department of Fish and Game (CDFG) as species of special concern; (5) are included on California Native Plant Society (CNPS) List 1A, 1B, 2, 3, or 4; (6) are considered sensitive or endemic by the U.S. Forest Service, Shasta-Trinity National Forest (USFS/STNF); (7) are considered a Survey and Manage species by the USFS/STNF (NSR 2004); or (8) are considered a CALFED Multi-species Conservation Strategy (MSCS) species. Below are species accounts for special-status species that may be affected by the Shasta Lake Water Resources Investigation (SLWRI).

Special-status Aquatic Species in Shasta Lake and Tributaries

Hardhead

Hardhead (*Mylopharodon conocephalus*) is a large (occasionally exceeding 600 mm standard length [SL]), native cyprinid species that generally occurs in large, undisturbed low- to mid-elevation rivers and streams of the region (Moyle 2002). The elevational range of hardhead is 10-1,450 m (Reeves 1964). The species is widely distributed throughout the Sacramento-San Joaquin River system, though it is absent from the valley reaches of the San Joaquin River. Hardhead mature following their second year. Spawning migrations, which occur in the spring into smaller tributary streams, are common. The spawning season may extend into August in the foothill streams of the Sacramento and San Joaquin River basins. Spawning behavior has not been documented, but hardhead are believed to elicit mass spawning in gravel riffles (Moyle 2002).

Most streams in which they occur have summer temperatures in excess of 20°C (68°F), and optimal temperatures for hardhead (as determined by laboratory choice experiments) appear to be 24-28°C (75-82°F) (Knight 1985). However, in a natural thermal plume, hardhead generally selected temperatures of 17-21°C (63-70°F) (cooler, but usually not warmer, temperatures were available).

Hardhead require large to medium-sized, cool to warm-water streams with natural flow regimes for their long-term survival. Because such streams are increasingly dammed and diverted, thus eliminating habitat, isolating upstream areas, or creating temperature and flow regimes unsuitable for hardhead, populations are declining or disappearing gradually throughout its range. A particular problem seems to be predation by smallmouth bass. Brown and Moyle (1993) observed that hardhead disappeared from the upper Kings River when the reach was invaded by the bass; a similar situation exists in the South Fork Yuba River (Gard 1994).

Hardhead can colonize reservoirs but will persist only if exotic species, especially centrarchid basses, are not abundant. The few reservoirs in which they are abundant today are those in which water-level fluctuations (such as for power-generating flows) prevent exotic species from reproducing. However, either stabilization of water levels or increasing the amount of seasonal fluctuation of these reservoirs can result in increased populations of centrarchid basses and decreased hardhead populations. Hardhead occurs throughout the primary study area for the SLWRI. In the Shasta Lake area, hardhead is generally a riverine species that spawns in rivers and creeks but is also found in the lake. Hardhead is a CDFG species of special concern and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions must maintain the status of hardhead and that any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures for the species are identified in Appendix D of this report.

California Roach

California roach (*Hesperoleucus symmetricus*), of which the Pit and San Joaquin roaches are a subspecies, are generally found in small, warm intermittent streams, and dense populations are frequently found in isolated pools (Moyle 2002). They are most abundant in mid-elevation streams in the Sierra foothills and in the lower reaches of some coastal streams (Moyle 2002). Roach are tolerant of relatively high temperatures (86°F to 95°F (30 – 35^{o}C)) and low oxygen levels (1 ppm to 2 ppm) (Knight 1985, Taylor *et al*. 1982, Cech *et al*. 1990, Leidy 1984). Roach reach sexual maturity by about the second year (approximately 45 mm SL). Reproduction generally occurs from March to June, usually when temperatures exceed 60.8°F, but may be extended through late July (Moyle 2002). California roach occurs throughout the primary study area for the SLWRI. California roach is a CDFG species of special concern.

Rough Sculpin

Rough sculpin *(Cottus asperrimus*) are largely restricted to spring-fed tributaries of the Pit River in northeastern Shasta County where water is cool (usually around 15^{o}C (59^{o}F), deep (often > 1 m, although they are most abundant at 50-75cm), rapidly flowing, and remarkably clear (Moyle 2002, Daniels and Moyle 1978, Brown 1991). In these streams they are associated with gravel or sand bottoms and beds of aquatic plants. Rough sculpins become increasingly stressed as temperatures become higher than 15^{o}C and die as temperatures exceed 25-27^{o}C (77-80.6^{o}F) for extended periods (Brown 1989). Dominant prey for rough sculpin are chironomid midge and baetid mayfly larvae (Moyle 2002). Spawning occurs between September and January in Fall River but from mid-February to early May in Hat Creek (Daniels and Moyle 1978, Daniels and Courtois 1982). Rough sculpin nest sites are in a wide variety of habitats, from riffles to pools, often active springs, with bottom substrates ranging from sand to cobble (Daniels 1987). Threats to rough sculpin include dewatering of habitat for power production and increased turbidity and contaminants due to changes in land use (*i.e.*, development, logging, grazing, and fires (Moyle 2002). The rough sculpin is a California threatened species, a CDFG Fully Protected species, and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions must maintain the status of rough sculpin and that any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures for the species are identified in Appendix D of this report.

<u>Special-status Floral Species in the Vicinity of Shasta Lake</u>

Shasta Snow-Wreath

The Shasta snow-wreath (*Neviusia cliftonii*) is an understory shrub in the rose family that was recently discovered in 1993 (Taylor 1993). The species is endemic to the southeastern Klamath Mountains in northern California (Ertter 1993), occurring in the vicinity of Shasta Lake within an elevational range from 1,070 feet (lake level) to 1,900 feet (Lindstrand 2007). *N. cliftonii* is one of only two known species of the genus *Neviusia*; the other species, Alabama snow-wreath (*N. alabamensis*), is a rare shrub that occurs only in the southeastern United States (Shevock *et al.* 1992). There are 21 known occurrences of the species, nine of which occur on limestone substrate (Lindstrand and Nelson 2005a,b; CDFG 2007a; Lindstrand 2007). The species occurs primarily along drainages in dense, shady montane hardwood-conifer and ponderosa pine forests, but also in foothill pine-blue oak woodland habitat (Lindstrand and Nelson 2005a,b). Populations occur within the Whiskeytown-Shasta-Trinity National Recreation Area, Shasta-Trinity National Forest, and on private land (Shevock 1993). Likely due to the initial construction of Shasta Dam, the remaining populations of Shasta snow-wreath are highly fragmented. There is no genetic information at this time to evaluate how genetically uniform the isolated populations are. Potential threats to the species include logging, mining, forest fires, invasive species, and the proposed raising of Shasta Dam in SLWRI (Shevock *et al.* 1992, CNPS 2007). Shasta snow-wreath is a slow growing species with a tendency to occur in relatively disturbed areas along the edge of the forest thus making the species especially vulnerable to invasive species (*i.e.*, blackberry) and human-related threats (J. Nelson, Shasta-Trinity National Forest, pers. comm, 2007). There is no information available at this time on the effects of fire on Shasta snow-wreath.

Shasta snow-wreath is an USFS sensitive species, a CALFED MSCS species, and a CNPS 1B.2 species. The CALFED Final Programmatic EIS/EIR includes Shasta snow-wreath among a list of "evaluated species for which direct mortality as a result of implementing CALFED actions is prohibited as a condition of the Multi-Species Conservation Strategy [MSCS] . . . .The MSCS requires CALFED to avoid all actions that could result in the mortality of any species identified in this table. This conservation measure was developed because these species are extremely rare. For may of the plants identified, fewer, than a dozen known populations exist" (see Table 4-5 in MSCS section of CALFED 2000b). Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this report.

During botany surveys and vegetation and habitat mapping surveys (NSR 2004, Lindstrand and Nelson 2005a,b, Lindstrand 2007), Shasta snow-wreath was found at nine sites within the Inundation Zone of the SLWRI. Therefore, 43 percent (9 of 21 subpopulations) of the entire known population of Shasta snow-wreath would be lost (or partly lost) by the proposed raising of Shasta Dam; other subpopulations could potentially be disturbed by the relocation of roads, bridges, campgrounds, and other facilities due to the SLWRI (Lindstrand 2007). The subpopulations found within the Inundation Zone include: (1) a single, relatively large population occurring in riparian habitat along the Ripgut Creek riverine reach (Pit River arm); (2) a large, previously known population along Campbell Creek (McCloud River arm); (3) a very large population in riparian habitat along both sides of Stein Creek (Pit River arm) extending from near the Stein Creek/Shasta Lake confluence to 0.25 mile upstream; (4) a small population found at an unnamed stream south of Cove Creek in riparian and mixed woodland habitat on the right bank, at the confluence with Shasta Lake; (5 and 6) one moderate and one large population along Blue Ridge on the main body of Shasta Lake in hardwood-conifer and ponderosa pine habitats immediately above the Shasta Lake high water line; and (7) a moderate-sized population in riparian habitat along both banks of Keluche Creek (McCloud River arm) near the Keluche Creek/Shasta Lake confluence (NSR 2004, Lindstrand 2007).

In addition to the nine subpopulations within the Inundation Zone, another eight subpopulations of Shasta snow-wreath are potentially threatened by non-project related activities due to their location adjacent to State highways, county roads, forest roads, trails, homes, transmission lines, and invasive species (Lindstrand 2007). Therefore, only 19 percent of all the known populations of Shasta snow-wreath (4 out of 21 subpopulations) are not currently threatened by SLWRI or non-project related activities (Lindstrand 2007).

Cantelow's Lewisia

Cantelow's lewisia (*Lewisia cantelovii* J. T. Howell) is a rare perennial herb and one of three rare cliff-dwelling lewisias that are USFS sensitive species and a CNPS 1B.2 species. All three lewisia taxon prefer bedrock cliffs or rocky slopes in rugged river canyons that are typically moist in the winter and spring and bone dry by midsummer (Foster *et al.* 1997). Cantelow's lewisia occurs at elevations of 400–1,300 m from the inner gorges of the Yuba River north to the Feather River watershed and occurs in two disjunct populations known from the middle reaches of the Shasta Reservoir (Foster *et al.* 1997, Hickman 1993). There is a lack of consensus on whether saw-toothed lewisia (*L. serrata* sensu stricto) should be classified as is its own distinct species or a subspecies of *L. cantelovii* (Foster *et al.* 1997, Hickman 1993) which raises questions about conservation priorities. Isozyme analysis (a technique that can identify genetic differences within groups of plants or animals) supports the recognition of saw-toothed lewisia as a separate species (Foster *et al.* 1997). Saw-toothed lewisia is endemic to the canyons of the American River and its tributaries. Potential threats to Cantelow's lewisia, and the other lewisia taxon, include horticultural collection, road maintenance, and hydroelectric development (Foster *et al.* 1997).

Cantelow's lewisia potentially occurs on rocky outcrops within chaparral, cismontane woodland and lower montane coniferous forest habitats within the SLWRI primary study area around Shasta Lake. One population was observed within the Inundation Zone on a rock outcrop on the right bank of the Upper Sacramento River riverine reach near the Shasta Lake/Upper Sacramento River transition zone (NSR 2004).

Shasta Clarkia

Shasta clarkia (*Clarkia borealis* ssp. *arida*) is a rare annual herb with a distribution limited to lower montane woodland and coniferous forest habitat within an elevation range of 490 – 595 m within southern Shasta and northern Tehama counties in northern California (CNPS 2007). Shasta clarkia is known from only six occurrences (CDFG 2007a). The closest known occurrence to Shasta Lake is less than 2.5 km southeast of the Pit River arm and 1.44 km northwest of the town of Ingot, Shasta County; this occurrence includes 1,000 plants on U.S. Bureau of Land Management land on cut and fill slopes along Sugar Pine Camp Road (CDFG

2007a). There is not enough information at this time on the distribution of Shasta clarkia in the vicinity of Shasta Lake to determine if the plant would be affected by the SLWRI. Another occurrence of *Clarkia borealis* was reported near Allie Cove about 275 m south of Shasta Lake. This occurrence was assumed to be northern clarkia (*Clarkia borealis* ssp. *borealis*) based on the range but the site is also close to the range of Shasta clarkia (CDFG 2007a); more fieldwork is required to verify the identity of this occurrence. Shasta clarkia is a CNPS 1B.1 species and a CALFED MSCS species. Like Shasta snow-wreath, the CALFED Final Programmatic EIS/EIR includes Shasta clarkia among a list of "evaluated species for which direct mortality as a result of implementing CALFED actions is prohibited as a condition of the Multi-Species Conservation Strategy " (see Table 4-5 in Multi-Species Conservation Strategy section of CALFED 2000b). Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this report.

Northern Clarkia

Northern clarkia (*Clarkia borealis* ssp. *borealis*) is a rare annual herb with a distribution limited to chaparral, cismontane woodland, and lower montane coniferous forest habitat within an elevation range of 490 – 1,340 m within Shasta County and extreme eastern Trinity County in northern California (CNPS 2007). Northern clarkia is a CNPS 1B.3 species and known from only 21 occurrences (CNPS 2007; CDFG 2007a). Three of the occurrences of northern clarkia are in the vicinity of Shasta Lake and likely to be affected by the SLWRI--two of the occurrences are adjacent to Shasta Lake and thus likely to be inundated while the third occurrence (near Allie Cove) is about 275 m from Shasta Lake (CDFG 2007a). These three occurrences are located (1) near Bailey Cove along both sides of Shasta Caverns Road next to the McCloud River arm; (2) near the town of Sugarloaf along Lakeshore Drive next to the Sacramento River arm; and (3) near Allie Cove on the mainbody of Shasta Lake (CDFG 2007a). A fourth occurrence of less than 1,000 northern clarkia plants is reported between Campbell Creek and the town of Delta on the east side of Sacramento River Canyon. It is not clear at this time if the plants in this occurrence would be affected by the SLWRI.

Silky Cryptantha

Silky cryptantha (*Cryptantha crinita*) is a rare annual herb with a distribution limited to cismontane woodland, lower montane coniferous forest, riparian forest, riparian woodland, valley and foothill grassland, and gravelly streambeds in Shasta and Tehama counties within an elevational range of 85 – 1,215 m (CNPS 2007). The closest known occurrence to Shasta Lake is about 7 km south of Allie Cove (CDFG 2007a). Silky cryptantha is a CNPS 1B.2 and a CALFED MSCS species. The plant species and is threatened by vehicles and gravel mining (CNPS 2007). The CALFED Programmatic EIR/EIS and ROD (CALFED 2000a,b) state that CALFED actions, such as the SLWRI, are prohibited from threatening the population viability of silky cryptantha. All CALFED actions must maintain the status of silky cryptantha and any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this report.

Shasta Huckleberry

Three populations of an unusual and undescribed huckleberry (unofficially known as "Shasta huckleberry") have been found in the last decade at two locations around Shasta Lake. The huckleberry most closely fits the description of red huckleberry (*Vaccinium parviflorum*) except that the berries of this taxon are dark blue (Nelson 2004). These inland populations are disjunct from the nearest known extant red huckleberry populations by about 40 miles, with the Trinity Alps and other Klamath Ranges lying between them (Nelson 2004). The Shasta huckleberry grows in a distinct, much less mesic habitat than does the coastal red huckleberry and apparently has adapted to grow on low pH soils with unique mineral compositions associated with abandoned mine sites (Nelson 2004; J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007). If Shasta huckleberry is a distinct genetic entity, it is a rare, geographically restricted taxon.

Shasta huckleberry is known from only three locations all near Shasta Lake: (1) scattered patches of shrubs along the Little Backbone Creek drainage from the confluence with Shasta Lake to about 1 mile upstream and uphill to the Golinski Mine; (2) along a road near Bully Hill Mine near the Squaw Creek arm; and (3) roadside and along a tributary at Shoemaker Gulch along County Road 5G12 to Bohemotash Mountain at an elevation of 2,600 ft (L. Lindstrand, NSR, pers. comm. 2007; J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007). Nine Shasta huckleberry shrubs occur within the Inundation Zone along the Little Backbone Creek drainage and thus are threatened by the SLWRI (L. Lindstrand, NSR, pers. comm. 2007). The Shasta huckleberry shrubs near Bully Hill Mine, while not within the Inundation Zone, are currently threatened by non-project related ground-disturbing activities associated with remediation of acid mine drainage on private land near Bully Hill Mine (J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007; L. Lindstrand, NSR, pers. comm., 2007). Shasta huckleberry shrubs at the Shoemaker Gulch site also occur along a road and are threatened by acid mine drainage and other human-related roadside disturbances (J. Nelson, Shasta-Trinity National Forest, pers. comm., 2007).

In May 2007, a preliminary genetic analysis of 5 microsatellite loci was conducted for a total of 75 Shasta huckleberry and red huckleberry genetic individuals by the National Forest Genetic Electrophoresis Laboratory in Placerville, California (DeWoody and Hipkins 2007). The genetic analysis indicated that despite the moderate sample size, allelic variation observed at three loci was remarkably high. This indicates that sufficient variation is resolved by these markers to distinguish between individuals and populations; however, the initial interpretations must be considered tentative and require additional collections and potentially different markers before a conclusion may be finalized (DeWoody and Hipkins 2007). Based on the data presented by DeWoody and Hipkins (2007), the genetic analysis is inconclusive; more samples and a different genetic analysis are required to make conclusions about the genetic distinctiveness of Shasta huckleberry.

In summary, at this time, Shasta huckleberry has not been officially identified as a distinct genetic entity; thus Shasta huckleberry has no special-status.

Special-Status Mammals near Shasta Lake

Pacific Fisher

Fishers occur in the northern coniferous and mixed forests of Canada and northern contiguous United States, from the mountainous areas in the southern Yukon and Labrador Provinces in Canada southward to central California and Wyoming, the Great Lakes, New England, and Appalachian regions (Graham and Graham 1994; Powell 1994). The current distribution of fishers is much reduced from the historical distribution (Gibilisco 1994). The distribution has recovered since the 1950s in some of the central and northeastern areas, a change attributed to factors such as trapping closures and reintroductions (Brander and Books 1973; Powell and Zielinski 1994).

In California, the fisher historically ranged throughout forested lands of the Sierra Nevada from Greenhorn Mountain in northern Kern County northward to the southern Cascades at Mount Shasta, and from the Klamath Mountains and north Coast Range near the Oregon border southward to Lake and Marin Counties (Grinnell *et al.* 1937). By the mid-1920s, the fisher was considered to still occur in much of its historical range in California, but at "markedly reduced" numbers (Grinnell *et al.* 1937). Recent surveys suggest there has been a reduction in the occupied range since the early 1900s, particularly in the central and northern portions of the Sierra Nevada (Zielinski *et al.* 1995). Currently, there are two known populations in California, one in the northwestern part of the State (extending into southwestern Oregon) and the other in the southern Sierra Nevada, separated by approximately 260 miles (mi) (420 km) (Zielinski *et al.* 1995). The extent of this separation is far beyond the species' known maximum dispersal distance. The State considers the fisher to be a ''Species of Special Concern.''

In the western United States, fisher denning and resting sites are forest stands with complex structural characteristics that are typical of late successional forests (Powell and Zielinski 1994; Seglund 1995; Dark 1997; Truex *et al.* 1998; Carroll *et al.* 1999; USFS 2000; Zielinski *et al.* 2004). These characteristics include large trees and snags, coarse down woody-debris and other complex structure near the ground, a high amount of canopy closure and overhead cover, and multiple-layered vegetation. Large tree cavities and snags in areas of dense canopy cover are often used as natal and maternal den sites (Lewis and Stinson 1998; USFS 2000); this may provide kits protection from predators while the mother is hunting (Lewis and Stinson 1998).

Late-successional coniferous or mixed forests are considered to provide the most suitable fisher habitat because they provide abundant potential den sites and preferred prey species (Allen 1987). However, according to Powell (1993), forest type is probably not as important as the vegetative and structural aspects that lead to abundant prey populations and reduce fisher vulnerability to predation. Younger forests in which complex forest floor components such as large logs, snags, and tree cavities are maintained in significant numbers, and which provide a diverse prey base, may be suitable habitat for the fisher (Lewis and Stinson 1998). Powell and Zielinski (1994) concluded that although there has been some indication of fishers being detected in second-growth forests and areas with limited overhead canopy, it was not known whether the use was transient or based on stable (regularly used) home ranges. Based on their work and a review of other information, Powell and Zielinski stated that early- and mid-successional forests are unlikely to provide the same prey resources, rest sites, and den sites as more mature forests.

They also suggested that habitat for resting and denning sites may be more limiting for fishers than foraging habitat.

Fishers have been found to be associated with riparian areas (Aubry and Houston 1992). Forested riparian areas often are protected from logging and generally are more productive, thus having the dense canopy closure, large trees, and general structural complexity such as broken top trees, snags, and coarse woody debris, all of which provide important rest site elements (Seglund 1995; Dark 1997).

Fishers avoid areas with little forest cover or significant human disturbance and conversely prefer large areas of contiguous interior forest (Rosenberg and Raphael 1986; Powell 1993; Jones and Garton 1994; Seglund 1995; Dark 1997). At a landscape scale, patches of preferred habitat and the location of open areas with respect to these patches may be crucial to the distribution and abundance of fishers in an area; fishers will probably use patches of preferred habitat that are interconnected by other forest types, whereas they will not likely use patches of habitat that are separated by sufficiently large open areas (Buskirk and Powell 1994). Riparian corridors (Heinemeyer and Jones 1994) and forested saddles between major drainages (Buck *et al.* 1983) may provide important dispersal habitat or landscape linkages (travel corridors) for the species.

The fisher is a generalized predator with a diverse diet that includes snowshoe hares (*Lepus americanus*), porcupines (*Erithizon dorsatum*), birds, squirrels, mice, shrews, voles, reptiles, insects, deer carrion, vegetation, and fruit (Powell 1993; Martin 1994; Zielinski *et al.* 1999; Zielinski and Duncan 2004). They usually hunt on the ground and occasionally hunt in trees (Raine 1987; Powell 1993). Other than the breeding season, fishers are solitary. Their home ranges are large, varying across North America from 3,954 to 30,147 ac (16 to 122 km2) for males and from 988 to 13,096 ac (4 to 53 km2) for females (Powell and Zielinski 1994; Lewis and Stinson 1998). Fishers have a low annual reproductive capacity. Males may not be effective breeders until they are 2 years old (Powell 1993). Females breed at the end of their first year, but because of delayed embryo implantation, do not produce a litter until their second year. Not all females produce young every year. Litters usually consist of 2 to 3 kits, and are raised entirely by the female. Kits have developed their own home ranges by age 1 (Powell 1993). Although relatively little information exists on dispersal by young, recent evidence suggests that only juvenile males disperse long distances, which would affect the rate at which the fisher may be able to colonize formerly occupied areas within its historical range (Aubry *et al.* 2006).

Fishers are estimated to live up to 7 to 10 years of age in the wild (Powell 1993). The most commonly reported mortality factors include predation, incidental trapping (*i.e.*, in traps set for other species), and being struck by vehicles (*e.g.*, Buck *et al.* 1994; Lewis and Zielinski 1996; Lewis and Stinson 1998; Truex *et al.* 1998).

On July 3, 2003, the Service found that a 90-day petition presented substantial information that the West Coast population of the fisher (including California, Washington, and Oregon) may be a distinct population segment (DPS) for which listing is warranted (68 FR 41169). The Service initiated a status review to determine if the listing of the fisher DPS is warranted. At this time, the Pacific fisher is a Federal candidate species, a California Special Concern Species, and a USFS and Bureau of Land Management (BLM) sensitive species.

Ringtail

The ringtail (*Bassaricus astutus*) occurs primarily in the Coast and Sierra Nevada mountain ranges from Oregon to the California-Mexico border (Belluomini 1980) with the greatest abundance along riparian areas in northern California and the Sierra Nevada foothills (Orloff 1980). Ringtails live in a variety of habitats within their range, but they have a decided preference for chapparal, rocky hillsides and riparian areas. Their denning areas include rock crevices, boulder piles, underground cavities, hollow trees or underground in hollow roots of trees (Belluomini 1980). Ringtails are opportunistic feeders that rely primarily on insects, fruits, and berries in addition to birds and mammals (Belluomini 1980). Ringtails generally produce 3-4 kits per litter during the months of May and June (Belluomini 1980). Prior to 1967, ringtails were trapped for their fur. The species potentially occurs in mixed conifer, conifer-woodland, riparian, and mixed chaparral habitats near Shasta Lake. Ringtails were observed at numerous sites within the SLWRI Inundation Zone during 2003 forest carnivore surveys in Big Backbone and Squaw Creek arms (NSR 2004). The ringtail is a California Fully Protected species and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions must maintain the status of the ringtail and that any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this report.

Greater Western Mastiff-Bat

The greater western mastiff-bat (*Eumops perotis californicus*) ranges from central Mexico across the southwestern United States (parts of California, southern Nevada, Arizona, southern New Mexico and western Texas). Recent surveys have extended the previously known range to the north in both Arizona (several localities near the Utah border) and California (to within a few miles of the Oregon border) (Texas Parks and Wildlife Department 2007, CDFG 1986a). In California, the greater western mastiff-bat is most frequently observed in broad open areas. This bat can be found in a variety of habitats from dry desert washes, flood plains, chaparral, oak woodland, open ponderosa pine forest, grassland, montane meadows, and agricultural areas (Texas Parks and Wildlife Department 2007, CDFG 1986a). It is primarily a cliff-dwelling species but is also found in crevices in large boulders. Roosts are generally high above the ground with a clear vertical drop of at least 9.8 feet below the entrance for flight. They appear to favor rugged, rocky areas where suitable crevices are available for day-roosts. Characteristically, day-roosts are located in large cracks in exfoliating slabs of granite or sandstone. The crevices must open downward, be at least 5 cm wide and 30 cm deep, and narrow to at least 2.5 cm at their upper end (CDFG 1986a). The decline of the species is likely due to urban, suburban and agricultural expansion, pesticides, draining of marshes, the loss of large open-water drinking sites, and activities that disturb or destroy cliff habitat (*e.g.*, water impoundments, highway construction, and quarry operations, recreational climbing) (Texas Parks and Wildlife Department 2007, CDFG 1986a). Several large bat caves were observed within the SLWRI Inundation Zone during field surveys, but the bat species was not identified (L. Lindstrand, NSR, pers. comm. 2007). The greater western mastiff-bat likely occurs in mixed conifer and conifer-woodland habitats near Shasta Lake (NSR 2004). The greater western mastiff-bat is a California species of special concern and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions must maintain the status of the greater western mastiff-bat and that any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this report.

Other Bat Species

Other sensitive and special-status bat species with the potential to occur near Shasta Lake include the western red bat (*Lazarus blossevillii*), spotted bat (*Euderma maculatum*), Townsend's big-eared bat (*Plecotus townsendii*), pallid bat (*Antrozous pallidus*), small-footed myotis (*Myotis ciliolabrum*), long-eared myotis (*Myotis volans*), and Yuma myotis (*Myotis yumanensis*) (NSR 2004). All of these bat species potentially occur in mixed conifer and conifer-woodland habitats near Shasta Lake and throughout the Inundation Zone (NSR 2004). The spotted bat, Townsend's big-eared bat, and pallid bat are California species of special concern. The western red bat, Townsend's big-eared bat, and pallid bat are USFS sensitive species. Several large bat caves were observed within the Inundation Zone near Shasta Lake during field surveys, but the particular bat species were not identified (L. Lindstrand, NSR, pers. comm., 2007).

Survey and Manage Terrestrial Mollusks near Shasta Lake

Survey and Manage terrestrial mollusk surveys were conducted by NSR during two rounds of surveys in both Big Backbone Creek and Squaw Creek arm portions of the Inundation Zone between December 2002 and February 2003. Four Survey and Manage terrestrial mollusk species were found: Shasta chaparral snail (*Trilobopsis roperi*), Shasta hesperian snail (*Vespericola shasta*), Shasta sideband (*Monadenia troglodytes troglodytes*), and Wintu sideband (*Monadenia troglodytes wintu*) (NSR 2004, Lindstrand 2007). The survey results, habitat requirements, and known locations of Shasta chaparral and Shasta hesperian are discussed below. On March 13, 2008, the Center for Biological Diversity petitioned for listing under ESA the 4 terrestrial mollusks among 28 other snails and slugs in the Pacific Northwest (Center for Biological Diversity 2008a,b).

Shasta Chaparral Snail

Shasta chaparral snail (*Trilobopsis roperi*) a terrestrial mollusk endemic to the southeastern Klamath Mountains in the vicinity of Shasta Lake (Lindstrand 2007). The terrestrial mollusk is known from only 12 sites in Shasta County, California, including three sites on non-Federal land and one site lost under Shasta Lake (Burke *et al.* 1999, Kelley *et al.* 1999). There are no currently protected occurrences of the species (Burke *et al.* 1999). Shasta chaparral snail is also expected to be found within the Whiskeytown-Shasta-Trinity National Recreation Area (Burke *et al.* 1999). The mollusk may be found within 100 meters of lightly to deeply shaded limestone rockslides, draws, or caves, with a cover of shrubs or oak (Kelley *et al.* 1999). During the wet season, it may be found away from refugia foraging for green vegetation and fruit, feces, old leaves, leaf mold, and fungi (Burke *et al*. 1999). Present knowledge of this species is based on limited collecting from known population areas in the 1930s. Significant data gaps exist in our knowledge of the species' biologic and environmental needs (Burke *et al.* 1999). Local and range-wide population trends are not known (Burke *et al.* 1999). Threats to the species include road building and substantial road maintenance, recreational usage, limestone quarrying, mining, and urbanization in the Redding area (Burke *et al.* 1999, Frest and Johannes 2000). Shasta chaparral snails were detected at 15 sites within the Inundation Zone along the Sacramento River, McCloud River, Squaw Creek, and Pit River arms (NSR 2004, Lindstrand 2007). On March 13, 2008, the Center for Biological Diversity petitioned for listing under ESA the Shasta chaparral snail (Center for Biological Diversity 2008a,b).

Shasta Hesperian Snail

Shasta hesperian snail (*Vespericola shasta*) is a small terrestrial mollusk endemic to Shasta County, California, primarily in the vicinity of Shasta Lake at an elevation of 244-853 meters (800-2,800 feet) (Kelley *et al.* 1999). The snail is known from only seven locations, all within the watershed of the upper Sacramento River in Shasta County including Lake Briton, Bernie Falls, and Lake Siskiyou (Burke *et al.* 1999; L. Lindstrand, NSR, pers. comm., 2007). The species has a discontinuous distribution becoming even more fragmented due to climate change, reservoirs, gold mining, and livestock grazing (Burke *et al.* 1999). The Shasta hesperian snail seems to be scarce to moderately common where it does occur, but the known locations are few and widely distributed; the snail species seems to be truly rare and vulnerable to extinction if there were adverse modifications of inhabited locations (Burke *et al.* 1999). Possible threats to the local survival of Shasta hesperian snail include loss of favorable microclimate through reduction or removal of riparian trees, the mechanical disruption of inhabited sites (by motor vehicles and earth-moving machinery), chemical pollution, invasion of the local ecosystem by nonnative plants and animals, and extensive removal of vegetation from watersheds that results in destructive floods and the loss of surface flow (Burke *et al.* 1999). There are no known protected occurrences of the species. Six of the historic locations for this species are within the administrative boundaries of Shasta National Forest (administered as Shasta-Trinity National Forests), but only one current location is known to be on Federal land. The six non-Federal locations are all within 1.6 km (1 mile) of Federal lands (Burke *et al.* 1999).

Shasta hesperian snail has been found in moist bottom lands, such as riparian zones, springs, seeps, marshes, and in the mouths of caves (Kelley *et al.* 1999). The snail seems to be restricted to isolated locations along the margins of streams where perennial dampness and cover can be found. Limestone in the alluvium of the streams of the upper Sacramento River system may contribute to habitat quality for this species. The relatively polished appearance of the shell of this species could be consistent with life in a stony environment--in contrast to other species of Vespericola that have a "furry" appearance and live on the soft surfaces of leaves and rotten wood on damp forest floors (Burke *et al.* 1999).

Shasta hesperian was detected at 31 sites within the Inundation Zone (NSR 2004, Lindstrand 2007). Shasta hesperian is currently designated as Category A species under the Northwest Forest Plan 2002 Survey and Manage Standards and Guidelines category Assignment (Bureau of Land Management [BLM] 2003) (2002 Category Assignment). Taxa in this category are considered rare, and preservation of all known sites or population areas is likely to be necessary to provide reasonable assurance of species persistence. On March 13, 2008, the Center for Biological Diversity petitioned for listing under ESA the Shasta hesperian snail (Center for Biological Diversity 2008a,b).

Shasta Sideband

Shasta sideband (*Monadenia troglodytes troglodytes*) is a terrestrial mollusk endemic to the southeastern Klamath Mountains in the vicinity of Shasta Lake up to an elevation of 3,000 – 3,500 ft (Lindstrand 2007). Shasta sideband occurs within conifer, hardwood-conifer, hardwood, and chaparral general habitat types but appears to be restricted to larger limestone outcrops with deep crevices along the McCloud River arm within the vicinity of Shasta Lake (Roth 1981, Lindstrand 2007). Shasta sidebands were found at four sites within the Inundation Zone along the McCloud River arm (Lindstrand 2007). It is not known at this time what percent of the population occurs within the Inundation Zone. Shasta sideband is a USFS Survey and Manage Species – Category A, a USFS Region 5 Sensitive species, and a CALFED MSCS species. The CALFED Programmatic EIR/EIS and ROD (CALFED 2000a,b) state that CALFED actions, such as the SLWRI, are prohibited from threatening the population viability of Shasta sideband. All CALFED actions must maintain the status of the Shasta sideband and any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this report. On March 13, 2008, the Center for Biological Diversity petitioned for listing under ESA the Shasta sideband (Center for Biological Diversity 2008a,b).

Wintu Sideband

Wintu sideband (*Monadenia troglodytes wintu*) is a terrestrial mollusk endemic to the southeastern Klamath Mountains in the vicinity of Shasta Lake up to an elevation of 3,000 – 3,500 ft (Lindstrand 2007). Wintu sideband, like Shasta sideband, occurs within conifer, hardwood-conifer, hardwood, and chaparral general habitat types but appears to be restricted to larger limestone outcrops with deep crevices in the vicinity of Shasta Lake between the Pit River and Squaw Creek, with one disjunct, outlying population south of Shasta Lake along the Pit River arm within the vicinity of Shasta Lake (Roth 1981, Lindstrand 2007). Wintu sidebands were found at two sites within the Inundation Zone along the Pit River arm (Lindstrand 2007). It is not known at this time what percent of the population occurs within the Inundation Zone. Wintu sideband is a USFS Survey and Manage Species – Category A and a USFS Region 5 Sensitive species. On March 13, 2008, the Center for Biological Diversity petitioned for listing under ESA the Wintu sideband (Center for Biological Diversity 2008a,b).

Special-Status Amphibians and Reptiles near Shasta Lake

Shasta Salamander

The Shasta salamander (*Hydromantes shastae*) is an uncommon and highly restricted species with a somewhat discontinuous distribution of small, isolated populations occurring in limestone areas (and in some non-limestone areas) in valley-foothill hardwood-conifer, ponderosa pine and mixed conifer habitats in the vicinity of Shasta Lake generally at elevations of 800 – 2,000 ft with a few occurrences between 2,000 – 3,800 ft (Lindstrand 2000; Lindstrand 2007, Morey *et al.* 2005). Each population is unique and vulnerable because of highly restricted habitat requirements (Morey *et al.* 2005). Shasta salamanders feed on centipedes, spiders, termites, beetles, and adult and larval flies (Stebbins 1972, Gorman and Camp 1953). Individuals are active on the surface nocturnally during rainy periods of all, winter, and spring. Shasta salamander was previously thought to be restricted to limestone fissures and caverns, or deep limestone talus (Morey *et al.* 2005); however, more recently, the species has been found in non-limestone habitat 2.4 – 6.4 km away from the nearest limestone formations (Lindstrand 2000; Lindstrand 2007). Limestone habitats are believed to act as natural reserves for the species during fires (K. Wolcott, Shasta-Trinity National Forest, pers. comm., 2007). The home range of Shasta salamanders is believed to be less than 100 m (328 ft) with most individuals moving much shorter distances (Morey *et al.* 2005). Shasta salamanders breed and lay clusters of nine to twelve eggs on damp limestone cavern walls in late summer. Young salamanders are thought to hatch in late fall (Gorman 1956, Papenfuss and Carufel 1977). Commercial demand for limestone may jeopardize existing populations (Morey *et al.* 2005).

Shasta salamander surveys were conducted between January – March 2003 within the Inundation Zone in the Big Backbone Creek and Squaw Creek arms. Shasta salamanders were observed at five sites within the Inundation Zone in the Big Backbone Creek survey area, but none were observed in the Squaw Creek survey areas. Shasta salamanders were also observed at two discovery sites during the terrestrial mollusk surveys performed within the Big Backbone Creek arm portion of the Inundation Zone (NSR 2004).

The Shasta salamander is a California threatened species and an USFS sensitive and Survey and Manage species. The CALFED Programmatic EIR/EIS and ROD (CALFED 2000a,b) state that CALFED actions, such as the SLWRI, are prohibited from threatening the population viability of Shasta salamander. All CALFED actions must maintain the status of the Shasta salamander and any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this report.

Foothill Yellow-Legged Frog

The foothill yellow-legged frog (*Rana boylii*) occurs in stream and riparian habitats near Shasta Lake. The species needs some flowing water and prefer streams; however, they can use bedrock pools while waiting for stream flow to return. Streams containing bullfrogs are not suitable habitat for foothill yellow-legged frog. There are several known occurrences of the species scattered throughout the Inundation Zone and vicinity (NSR 2004). About 35 percent of the 220 low slope perennial streams around Shasta Lake could be considered habitat for the foothill yellow-legged frog (L. Lindstrand, NSR, pers. comm.). The foothill yellow-legged frog is a California species of special concern, USFS sensitive species, and a CALFED MSCS species. All CALFED actions must maintain the status of the foothill yellow-legged frog and any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this report.

California Red-Legged Frog

The California red-legged frog (*Rana aurora draytonii)* is federally listed as threatened under the ESA. The Shasta Lake vicinity is within the known historic range of the species. The species is generally found in flat water, including deep pools and ponds lacking bullfrogs. Additional information about the California red-legged frog and other federally listed species will be provided in the ASIP and the Service's biological opinion for the SLWRI project.

Northwestern Pond Turtle

The northwestern pond turtle (*Clemmys marmorata marmorata*) occurs in stream and other wetland habitats in the vicinity of Shasta Lake. Adjacent upland habitats are potential nesting areas. Habitat requirements include basking logs and rocks, as well as slow moving water or ponds. There are several known occurrences of the northwestern pond turtle scattered throughout the SLWRI Inundation Zone and vicinity in tributaries to the lake and around the lake shallows (NSR 2004). The northwestern pond turtle is a California species of special concern, USFS sensitive species, and a CALFED MSCS species. All CALFED actions must maintain the status of the northwestern pond turtle and any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures recommended by the CALFED MSCS are identified in Appendix D of this report.

Migratory and Special-Status Bird Species near Shasta Lake

Western Purple Martin

Western purple martins (*Progne subis arboricola*) are generally uncommon and very local throughout California so all breeding locations are of considerable importance to the species' California range. The Pacific Coast western purple martin population has substantially declined in the last 50 – 100 years primarily due to coastal lowland urban and agricultural development, forest management and fire suppression that have reduced the availability of large snags for nesting use, and increased competition with introduced and European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*) for a dwindling supply of natural nest cavities (Western Purple Martin Working Group 2005). The current population estimate for purple martins in California, Oregon, Washington, and British Columbia is about 3,500 pairs (1,300 pairs in California) (Western Purple Martin Working Group 2005). Western purple martins nest in small colonies in large snags where there are multiple natural cavities or cavities made by the larger woodpeckers such as acorn and Lewis' woodpeckers and flickers (Siegel and DeSante 1999).

At Shasta Lake, there appears to be a stable population of 18 pairs of purple martins that nest in the inundated snags in the Pit River arm (Lindstand 2007). These inundated snags were created when the Pit River arm was not logged prior to the initial construction of Shasta Dam. Shasta Lake represents 14 – 51 percent of the total interior Northern California population of western purple martins (Williams 1998). In April and May, western purple martins begin to build there nests in the natural cavities of inundated snags in the Pit River. Western purple martins select for inundated snags and, unlike the more widespread eastern purple martins, they are not known to use artificial structures for nesting. In California, about 85 percent of western purple martins nest in natural cavities with the remaining 15 percent nesting in bridges and power poles (Western Purple Martin Working Group 2005). The interim objective for recovery within California is to retain at least 75 percent of the population nesting in natural cavities (Western Purple Martin Working Group 2005).

A raise in Shasta Dam would likely completely submerge suitable nesting habitat for western purple martins. Although new inundated snags would likely be created by the dam raise, there would be a time lag on the order of decades before the newly inundated snags would provide suitable nesting habitat. The western purple martin is a CDFG species of special concern.

California Yellow Warbler

The California yellow warbler (*Dendroica petechia brewsteri*) often nests in deciduous riparian plant species, such as willows and cottonwoods, but also breeds locally in wild rose and more xeric plant species and habitats. The bird is generally found in wet areas with early successional riparian communities, or in remnant or regenerating canopy species stands. The California yellow warbler will also breed locally in xeric shrub fields. In the Sacramento and San Joaquin Valleys, Himalayan blackberry and valley oak positively influence the abundance of California yellow warblers (RHJV 2004). In the Sierra Nevadas, grass and willows positively influence yellow warbler species occurrence and wild rose increases nesting success (RHJV 2004). The California yellow warbler is extirpated or declining in much of its historical breeding range. The biggest threats to the California yellow warbler are brown-headed cowbird parasitism and reduction in the quality of nesting habitat due to grazing or water diversions (RHJV 2004). Lower Clear Creek supports the largest concentration of California yellow warblers in the Sacramento Valley region. Therefore, RHJV prioritizes ensuring a continuous riparian corridor from Clear Creek to the main stem of the Sacramento River and improving habitat quality through restoration and restoring natural processes (RHJV 2004). California yellow warblers are known to breed in valley floor riparian and montane riparian habitat near Shasta Lake. They are distributed throughout the Shasta Lake vicinity in areas with good riparian scrub. The California yellow warbler is a CDFG species of special concern and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions contribute to the recovery of the California yellow warbler by implementing some of the actions deemed necessary to recovery of the species' populations.

Little Willow Flycatcher

Historically, willow flycatchers (*Empidonax trailli*) nested throughout California wherever riparian deciduous shrubs, mainly thickets of willows, occurred (Grinnell and Miller 1944). Altitudes of known nestings occurred from within 30 m (100 ft.) of sea level to 2,440 m (8,000 ft.) (Grinnell and Miller 1944). The little willow flycatcher (*Empidonax trailli brewsteri*) breeds in California from Tulare County north, along the western side of the Sierra Nevada and Cascades, extending to the coast in northern California (Craig and Williams 1998). In California, it is a rare to locally uncommon summer resident in wet meadows and montane riparian habitats from 600 to 2,440 m (2,000-8,000 feet) in elevation and a common spring (mid-May to early June) and fall (mid-August to early September) migrant at lower elevations, primarily in riparian habitats, throughout the state exclusive of the North coast (Zeiner *et al.* 1990). Most of the remaining breeding populations occur in isolated mountain meadows of the Sierra Nevada and Cascades (Serena 1982, Harris *et al*. 1988). In mountain meadows, willow flycatchers appear to prefer nesting near the edges of vegetation clumps and near streams. In California, water is always present on willow flycatcher territories, in the form of running water, standing water (pools), or saturated soils during the early stages of the breeding season (Harris *et al*. 1988, Sanders and Flett 1989). The nesting period for willow flycatchers is 12 to 15 days.

Chicks can be present in the nest from mid-June through early August, and young fledge typically from late June through mid-August (Sogge *et al.* 1997). Threats to little willow flycatchers include brown-headed cowbird parasitism, riparian habitat loss and fragmentation, livestock grazing, timber harvest, and changes in natural hydrology due to water diversions, impoundments, and other land use practices. Within the Project area, the little willow flycatcher is known to occur in valley floor riparian and montane riparian habitat near Shasta Lake. The little willow fly catcher is a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions contribute to the recovery of the little willow fly catcher by implementing some of the actions deemed necessary to recovery of the species' populations.

Bald Eagle

Shasta Lake is home to the largest concentration of nesting bald eagles in California. Three bald eagle territories are present on the Sacramento River arm alone: Little Squaw, Bass Point, and Frost Gulch. Bald eagles also nest near Lake Britton and along the lower Pit River. The High Complex Fire of 1999, which killed numerous large pines, may have affected potential nesting and roosting areas around Shasta Lake (USBR 2007). Four of the 28 mapped bald eagle nests near Shasta Lake are located within the Inundation Zone (Lindstrand 2007). The four nest sites are located along the Middle Salt Creek, Salt Creek, Cove Creek, and Frenchman Gulch.

On June 28, 2007, the Service announced the recovery of the bald eagle and the final decision to remove it from the Federal list of threatened and endangered species. When the bald eagle was listed in 1967 as endangered under the forerunner of the Endangered Species Act, there were barely 400 nesting pairs in the entire lower 48 states. Now there are more than 9,700 nesting pairs in the lower 48 states.

Bald eagles continue to be protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Both acts prohibit killing, selling or otherwise harming eagles, their nests or eggs. On June 1, 2007, the Service announced a final definition of "disturb," National Bald Eagle Management Guidelines, and a proposed regulation, that if finalized, would establish a permit process to allow a limited amount of "take" consistent with the preservation of bald and golden eagles. However, until such a regulation is finalized, the Service does not have any authority to authorize "take" other than what currently exists in 50 CFR 22 (e.g., scientific, educational or religious purpose). The bald eagle continues to be listed by the State of California as endangered (CESA).

Osprey

The osprey (*Pandion haliaetus*) historically bred throughout much of California, but this species had declined by the 1940s (Grinnell and Miller 1944) and is now found mainly in a few areas in northern California. Reasons for the decline in ospreys include the removal of nesting trees, degradation of river and lake environmental quality, boating on nesting lakes, shooting, and pesticides (Remsen 1978a). Healthy populations of osprey occur just inland from the coast from Sonoma County north and in Shasta, Lassen, and Plumas counties. Ospreys are common around Shasta Lake with 51 known nest sites (Lindstrand 2007). The osprey is a CDFG species of special concern and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD

(CALFED 2000a,b) require that all CALFED actions must maintain the status of the osprey and that any adverse effects on the species must be fully offset through implementation of actions beneficial to the species.

American Peregrine Falcon

The California breeding range of the American peregrine falcon (*Falco peregrinus anatum*) has been expanding and includes the Channel Islands, coast of southern and central California, inland north coastal mountains, Klamath and Cascade ranges, and the Sierra Nevada (CDFG 2000). Nesting sites are typically on ledges of large cliff faces, but some pairs are nesting on city buildings and bridges. Nesting and wintering habitats are varied, including wetlands, woodlands, other forested habitats, cities, agricultural areas and coastal habitats. Peregrine falcons feed on birds that are caught in flight (CDFG 2000). The American peregrine falcon occurs in lacustrine and non-tidal permanent freshwater emergent habitat near Shasta Lake. Two nests are known to be in the lake area, but only one is known to be recurring. Because their nest sites (aeries) are on cliffs, they are not likely to be inundated by an 18.5-foot dam raise. On August 25, 1999, the Service delisted the American peregrine falcon due to continued recovery of the species. The American peregrine falcon is a CALFED MSCS species and continues to be listed by the State of California as an endangered and a Fully Protected species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions must maintain the status of the American peregrine falcon and that any adverse effects on the species must be fully offset through implementation of actions beneficial to the species.

Long-Eared Owl

The long-eared owl (*Asio otus*) was once a common resident in many parts of California, but began to decline by the 1940s (Grinnell and Miller 1944) and has continued to decline through the present. Areas in which the decline has been most severe are the Sacramento Valley, where it is probably extirpated, the San Joaquin Valley, and the San Diego area (Remsen 1978b). Possible causes of the decline of the bird include the destruction of lowland riparian woodland, vehicle strikes, shooting, and harassment (Remsen 1978b, Siegel and DeSante 1999). The habitat requirements for the long-eared owl are not well understood, but the species has the potential to occur in valley floor riparian, montane riparian, and oak-conifer woodland habitats near Shasta Lake and its tributaries (Siegel and deSante 1999). Little is known about the distribution of the species within the Shasta Lake area. Long-eared owl is CDFG species of special concern and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions must maintain the status of the long-eared owl and that any adverse effects on the species must be fully offset through implementation of actions beneficial to the species.

Great Blue Heron

The great blue heron (*Ardea herodias*) usually nests in colonies in the tops of secluded large snags or live trees, picking the tallest available. Tall riparian trees are needed for perching and roost sites. Also, secluded large snags or groves of live trees are needed for colony nesting. These need to be located within 10 miles of feeding areas (CDFG 2007d). Courtship and nest building begin shortly after February and the eggs are laid in late February or March. Great blue herons feed mostly on fish, frogs and crayfish, and occasionally mice and insects. Great blue herons are fairly common in shallow estuarine systems and fresh and saline emergent wetlands all year throughout California. They are somewhat less common along riverine systems, rocky coastlines, croplands, pastures, and in the mountains above the foothills (CDFG 2007d). Tree cutting, water recreation, draining of wetland habitats, building, and highway construction have all contributed to rookery abandonment in recent years (CDFG 2007d). A great blue heron rookery is known to occur in Turntable Bay near the confluence of the McCloud River arm with Shasta Lake (L. Lindstrand, NSR, pers. comm., 2007). The great blue heron is a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions must maintain the status of the great blue heron and that any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. The SLWRI is likely to inundate the shallow water habitat of the rookery at Turntable Bay.

Yellow-Breasted Chat

In California, yellow-breasted chats (*Icteria virens*) chats require dense riparian thickets of willows, vine tangles, and dense brush associated with streams, swampy ground and the borders of small ponds (Ricketts and Kus 2000). Some taller trees (*i.e.*, cottonwoods and alders) are required for song perches. Chats are reported to use Himalayan blackberry (*Rubus discolor*) as breeding habitat most likely use it throughout the state due to its dense thicket-forming properties. Therefore, any management efforts to remove this plant from riparian areas (*i.e.*, exotic removal programs) should first assess any detrimental effects the removal may have on local breeding chats (Zack *et al.* 1997). Spring migration occurs in March – May and fall migration in July – October (Ricketts and Kus 2000). Yellow-breasted chats are frequent hosts of brown-headed cowbirds (Ricketts and Kus 2000). Flood control and river channelization eliminate early successional riparian habitat that chats use for breeding (Ricketts and Kus 2000). Within the Klamath Region, yellow-breasted chats are likely threatened by logging activities (Ricketts and Kus 2000). Yellow-breasted chats are known to breed in valley floor and montane riparian habitat near Shasta Lake. The SLWRI is likely to inundate riparian breeding habitat of the yellow-breasted chat. The species is a CDFG species of special concern and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions must maintain the status of the yellow-breasted chat and that any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures for the species are identified in Appendix D of this report.

Northern Spotted Owl

The northern spotted owl (*Strix occidentalis caurina*) is federally listed as threatened under the ESA and is a CALFED MSCS species. Critical habitat for the northern spotted owl occurs in old growth forest near Shasta Lake. More information on the Northern spotted owl and other federally listed species will provided in the ASIP and the Service's biological opinion for the SLWRI project.

<u>California Partners in Flight Focal Bird Species in the Vicinity of Shasta Lake</u>

The California Partners in Flight (CalPIF) and Riparian Habitat Joint Venture (RHJV) publish Bird Conservation Plans for the major habitat types in the state of California (CalPIF 2000, CalPIF 2002a, CalPIF 2002b, CalPIF 2004, RHJV 2004). Each of the Bird Conservation Plans contains a list of focal bird species to be targeted for conservation for each major habitat type. CalPIF and RHJV maintain that the conservation recommendations for the focal species, if implemented, should benefit many species associated with that habitat type. Thus many of the focal bird species are included as evaluation species for the upland and riparian habitat types above. Below is a discussion of the CalPIF and RHJV focal bird species found near Shasta Lake.

In the Draft Grassland Bird Conservation Plan (CalPIF 2000), CalPIF identifies seven focal grassland bird species that are dependent on this habitat type: ferruginous hawk (*Buteo regalis*), grasshopper sparrow (*Ammodramus savannarum*), mountain plover (*Charadrius montanus*), northern harrier (*Circus cyaneus*), savannah sparrow (*Passerculus sandwichensis*), western meadowlark (*Sturnella neglecta*), and white-tailed kite *(Elanus leucurus)*.

In the Riparian Bird Conservation Plan (RHJV 2004), CalPIF and RHJV focus on the following bird species for conservation associated with montane riparian habitat near Shasta Lake: black-headed grosbeak (*Pheucticus melanocephalus*), common yellowthroat (*Geothlypis trichas),* song sparrow (*Melospiza melodia),* Swainson's thrush (*Catharus ustulatus*), tree swallow (*Tachycineta bicolor*), warbling vireo (*Vireo gilvus*), willow flycatcher (*Empidonax traillii*), Wilson's warbler (*Wilsonia pusilla*), yellow-breasted chat (*Icteria virens),* and yellow warbler (*Dendroica petechia*). But conservation recommendations, if implemented, should benefit many montane riparian associated species.

In the Oak Woodland Bird Conservation Plan (CalPIF 2002a), CalPIF focuses on the following bird species for conservation associated with oak woodland habitat near Shasta Lake: acorn woodpecker (*Melanerpes formicivorus*), blue-gray gnatcatcher (*Polioptila caerulea*), lark sparrow (*Chondestes grammacus*), Nuttall's woodpecker (*Picoides nuttallii*), oak titmouse (*Baeolophus inornatus*), western bluebird (*Sialia Mexicana*), western scrub-jay (*Aphelocoma californica*), and yellow-billed magpie (*Pica nuttalli*). But conservation recommendations, if implemented, should benefit many oak woodland associated species. The following discussion of focal bird species is taken from the Oak Woodland Bird Conservation Plan (CalPIF 2002a).

In the California Coniferous Forest Bird Conservation Plan (CalPIF 2002b), CalPIF focuses on the following bird species for conservation associated with coniferous forests near Shasta Lake: brown creeper (*Certhia americana*), black-throated gray warbler (*Dendroica nigrescens*), dark-eyed junco (*Junco hyemalias*), flammulated owl (*Otus flammeolus*), fox sparrow (*Passerella iliaca*), golden-crowned kinglet (*Regulus satrapa*), MacGillivray's warbler (*Oporornis tolmiei*), olive-sided flycatcher (*Contopus cooperi*), pileated woodpecker (*Dryocopus pileatus*), red-breasted nuthatch (*Sitta canadensis*), Vaux's swift (*Chaetura vauxi*), and western tanager (*Piranga ludoviciana*). But conservation recommendations, if implemented, should benefit many coniferous forest associated species.

In the Coastal Scrub and Chaparral Bird Conservation Plan (CalPIF 2004), CalPIF focuses on the following bird species for conservation associated with chaparral near Shasta Lake: greater roadrunner (*Geococcyx californianus*), mountain quail (*Oreortyx pictus*), and wrentit (*Chamaea fasciata*). But conservation recommendations, if implemented, should benefit many chaparral associated species.

Special-status Aquatic Species in the Sacramento River and Delta

Central Valley Winter-run Chinook Salmon

With the possible exception of Battle Creek, the upper Sacramento River is the only spawning stream of winter-run Chinook, which have been in a major decline since the 1960s. The return of only 696 adults in 1989 from an average annual population in the late 1960s of 80,000 adults prompted listing of winter-run Chinook salmon as an endangered species under both the Federal and State Endangered Species Acts, respectively. Since the mid-1990s, winter-run Chinook salmon populations have increased to about 7,500 – 8,200 during the years 2001 - 2004 (CDFG 2007b).

On June 16, 1993, NOAA Fisheries designated critical habitat for the winter-run Chinook salmon from Keswick Dam (Sacramento river mile 302) to the Golden Gate Bridge (58 FR 33212). The designated habitat includes the area from the Sacramento River at Keswick Dam downstream to San Francisco Bay. The open ocean was considered important, but was not designated as critical habitat because degradation of the open ocean did not appear to have significantly contributed to the decline of the species. The essential features of the critical habitat include 1) the river water, 2) the river bottom including those areas used as spawning substrate, 3) the adjacent riparian zone used for rearing, and 4) the estuarine water column and essential foraging habitat and food resources of the Delta and Bay, used for juvenile emigration and adult upmigration.

Adult winter-run Chinook salmon immigration and holding (upstream spawning migration) through the Delta and into the lower Sacramento River occurs from December through July, with a peak during the period extending from January through April (USFWS 1995a). Winter-run Chinook salmon primarily spawn in the main-stem Sacramento River between Keswick Dam (RM 302) and RBDD (RM 243). Winter-run Chinook salmon spawn between late-April and mid-August, with a peak generally in June. Winter-run Chinook salmon embryo incubation in the Sacramento River can extend into October (Vogel and Marine 1991).

Winter-run Chinook salmon fry rearing in the upper Sacramento River exhibit peak abundance during September, with fry and juvenile emigration past RBDD occurring from July through March (USBR 1992; Vogel and Marine 1991), although NOAA Fisheries (NOAA Fisheries 1993, 1997) report juvenile rearing and outmigration extending from June through April. Juvenile winter-run Chinook salmon that emerged in the mainstem Sacramento River may rear in tributaries to the Sacramento River. During investigations of nonnatal rearing of juvenile Chinook salmon in intermittent tributaries to the Sacramento River (Maslin *et al.* 1996, 1997, 1998, and 1998), 431 winter-run Chinook salmon were found in Mud Creek, near Chico, and Blue Tent Creek, near Red Bluff. Of the four runs of Chinook salmon, juvenile winter-run were found the farthest upstream in nonnatal tributaries with over 80 percent found more than 3 km upstream (Maslin *et al.* 1999). The authors hypothesized that winter-run Chinook salmon forage further upstream because food is scarcer when they arrive in tributaries that have just begun running (Maslin *et al.* 1999).

Both spring run and winter-run Chinook salmon were disproportionately abundant in the tributaries considering their scarcity in the Sacramento River system (Maslin *et al.* 1996).

Maslin *et al.* (1996) found that juvenile Chinook salmon rearing in the tributaries grew faster than in the mainstem Sacramento River. Faster growing fish smolt earlier, and may enter the Delta earlier in the year, before low water and pumping degrade rearing habitat. Optimal rearing conditions in tributaries exist from about December through March. Therefore, juvenile Chinook salmon entering the tributaries early in the year, such as winter-run and spring-run, probably derive the most benefit from tributary rearing (Maslin *et al.* 1996).

Additional information on the life history and habitat requirements of winter-run Chinook salmon is contained in the NOAA Fisheries Biological Opinion which was developed to specifically evaluate impacts on winter-run Chinook salmon associated with CVP and SWP operations (NOAA Fisheries 1993).

Central Valley Spring-run Chinook Salmon

Spring-run Chinook salmon were once the predominant run in the Central Valley, but have declined dramatically from historical numbers. Declines during 1950s are estimated at 90 percent compared to the period between 1916 and 1947. Estimated escapement (total number of adult salmon aged 2 years and older that escape the fishery and return to spawn) in the Sacramento River basin ranged from 3,000 to more than 31,000 adults between 1987 and 1999, averaging 11,155 (CDFG 2007b). In 2000 – 2006, estimated escapement in the Sacramento River basin ranged from about 9,250 – 17,600. Sporadic counts of spring-run Chinook salmon, beginning in the 1940s, indicate that a relatively large population once was present in Battle Creek (CDFG 1998). Estimates from recent years have ranged between 40 and 177 spring-run Chinook in Battle Creek (CDFG 2007b). The number of spring-run adult salmon passing the RBDD has fluctuated between highs of more than 25,000 fish to a low of about 770 in 1991 (CDFG 2007b). Currently, the major spawning populations of spring-run Chinook salmon are in the Feather River, Butte Creek, Mill Creek, and Deer Creek. Smaller spawning populations of 20 – 300 spring-run Chinook salmon are in Battle Creek, Clear Creek, Cottonwood Creek, Antelope Creek, and Big Chico Creek (CDFG 2007b). Because of the decline in spring-run salmon populations, the Central Valley spring-run Chinook salmon was state-listed as threatened on February 5, 1999, and federally listed as threatened on September 16, 1999. On September 2, 2005, NOAA Fisheries designated critical habitat for Central Valley spring-run Chinook salmon (70 FR 170) in the Sacramento-San Joaquin Delta, Yolo Bypass, Sacramento River and numerous tributaries of the Sacramento River.

There are no known spawning populations of spring-run Chinook salmon in the mainstem Sacramento River upstream of RBDD (Benthin *in litt.* 2006). However, small numbers of spring-run Chinook salmon (about 100 – 400) are thought to pass RBDD to spawn in tributaries to the Sacramento River such as Battle Creek, Clear Creek, and Cottonwood Creek (CDFG 2004, CDFG 2007b).

Spring-run Chinook salmon acquired and maintained genetic integrity through spatio-temporal isolation from other Central Valley Chinook salmon runs. Historically, spring-run Chinook salmon were temporally isolated from winter-run, and largely isolated in both time and space from the fall-run. Much of this historical spatio-temporal integrity has broken down, resulting in intermixed life history traits in many remaining habitats.

Sacramento River spring-run Chinook salmon are known to use the Sacramento River as a migratory corridor to spawning areas in upstream tributaries. Historically, spring-run Chinook salmon did not utilize the mainstem Sacramento River downstream of the Shasta Dam site except as a migratory corridor to and from headwater streams (CDFG 1998). Currently, it is unclear the extent to which spring-run Chinook salmon utilize the upper Sacramento River (*i.e.*, upstream of the RBDD and downstream of Keswick Dam) for other than a migratory corridor.

Adult spring-run Chinook salmon immigration and holding in California's Central Valley Basin occurs from mid-February through September (CDFG 1998; Lindley *et al.* 2004). Suitable water temperatures for adult upstream migration reportedly range between 57ºF and 67ºF (NOAA Fisheries 1997). In addition to suitable water temperatures, adequate flows are required to provide migrating adults with olfactory and other cues needed to locate their spawning reaches (CDFG 1998).

The primary characteristic distinguishing spring-run Chinook salmon from the other runs of Chinook salmon is that adult spring-run Chinook salmon hold in areas downstream of spawning grounds during the summer months until their eggs fully develop and become ready for spawning. Maximum water temperatures for adult spring-run Chinook salmon holding are reported to be approximately 59ºF to 60ºF (NOAA Fisheries 1997). Spring-run Chinook salmon reportedly spawn in the lower Yuba River, the lower Feather River and, to some extent, the mainstem Sacramento River. Spawning and embryo incubation has been reported to primarily occur during September through mid-February, with spawning peaking in mid-September (Moyle 2002; DWR 2004a; DWR 2004b; Vogel and Marine 1991).

Although some portion of an annual year-class may emigrate as post-emergent fry (individuals less than 45 mm in length), most are believed to rear in the upper Sacramento River and tributaries during the winter and spring and emigrate as juveniles (individuals greater than 45 mm in length, but not having undergone smoltification) or smolts (silvery colored fingerlings having undergone the smoltification process in preparation for ocean entry). It has also been reported that some spring-run Chinook salmon emigrate from natal streams soon after emergence during the winter and early-spring (NOAA Fisheries 2004a). In the Sacramento River drainage, spring-run Chinook salmon smolt emigration reportedly occurs from October through March (CDFG 1998). However, because spring-run Chinook salmon smolts reportedly emigrate from the Feather River system (*i.e.,* Feather and Yuba rivers) from October through June, and are presumably migrating through the Sacramento River to more saline environs in the Bay/Delta, the evaluation period for spring-run Chinook salmon smolt emigration in the Sacramento River is from October through June.

Central Valley Fall-run Chinook Salmon

Fall-run Chinook salmon were historically one of the more abundant salmon races in the Central Valley. Annual estimates of spawning escapement (total number of adult salmon aged 2 years and older that escape the fishery and return to spawn) in the mainstem Sacramento River have declined over the last 50 years. Annual run size of wild (not of hatchery origin) fall-run spawning above the RBDD declined from an average of about 100,000 adults in the mainstem and 16,000 in the tributaries during the 1950s and 1960s to an average of about 48,000 in the mainstem and 22,000 in the tributaries during the 1970s through about 2000 (CDFG 2007b). In

2001 – 2004, the number of wild fall-run spawning past the RBDD ranged from about 34,000 – 66,000 in the mainstem and 30,000 – 413,000 in the tributaries (CDFG 2007b). The total number of fall-run Chinook salmon for the entire Sacramento River system in 2001 – 2004 was about 362,000 – 836,000 of which 62,000 – 118,000 were of hatchery origin (CDFG 2007b). Fall-run Chinook salmon are currently a candidate species for Federal listing.

The timing of adult Chinook salmon spawning activity is strongly influenced by water temperatures. When daily average water temperatures decrease to at most 60°F, female Chinook salmon begin to construct nests (redds) into which their eggs (simultaneously fertilized by males) are eventually released. Fertilized eggs are subsequently buried with streambed gravel. Due to the timing of adult arrivals and occurrence of appropriate spawning temperatures, spawning activity in recent years in the lower American River, for example, has peaked during mid- to late-November (CDFG 1992; CDFG 1995). In general, the fall-run Chinook salmon spawning and embryo incubation period extends from October through March (NOAA Fisheries 2004a; Vogel and Marine 1991). It should also be noted that if water temperature conditions are sufficiently low (i.e., ≤ 60°F), spawning activity may begin in September (Moyle 2002).

The intragravel residence times of incubating eggs and alevins (yolk-sac fry) are highly dependent upon water temperatures. The intragravel egg and fry incubation life stage for Chinook salmon generally extends from about mid-October through March.

Water temperatures reported to be optimal for rearing of Chinook salmon fry and juveniles are between 45°F and 65°F (NOAA Fisheries 2002a; Rich 1987; Seymour 1956). Raleigh *et al.* (1986) reviewed the available literature on Chinook salmon thermal requirements and suggested a suitable rearing temperature upper limit of 75°F and a range of approximately 53.6°F to 64.4°F. The smoltification process may become compromised at water temperatures above 62.6°F (Zedonis and Newcomb 1997).

Central Valley Late Fall-run Chinook salmon

Between 2003 and 2006, the number of late fall-run Chinook salmon passing RBDD declined from an average of about 35,000 adults in the late 1960s to about 5,300 – 14,000 (USBR 2007, CDFG 2007b). Late fall-run salmon are also a candidate species for Federal listing. In 1999, the NOAA Fisheries determined that listing the Central Valley fall-/late fall–run Chinook salmon under the ESA was not warranted. However, this Ecologically Significant Unit remains a candidate for listing because it is unclear whether natural populations are self-sustaining and various risk factors still exist. Late fall-run Chinook salmon spawning habitat is limited to the mainstem Sacramento River upstream from RBDD and in Battle Creek (CDFG 2007b).

Central Valley Steelhead

Abundance of steelhead in the Sacramento River basin has declined significantly since the 1950s. The average annual run size in the Sacramento River above the mouth of the Feather River during 1953 through 1958 was estimated at 20,540 fish (Hallock 1989, Hallock *et al*. 1961). Annual counts at the RBDD declined from an average of 11,187 adult fish in the late 1960s and 1970s to 2,202 adult fish in the 1990s (McEwan and Jackson 1996). The Central Valley steelhead was federally listed as threatened on May 19, 1998 (63 FR 13347); the steelhead is not State-listed. On Sept. 2, 2005, NOAA Fisheries designated critical habitat for Central Valley steelhead in the San Joaquin River and tributaries, Sacramento-San Joaquin Delta, Yolo Bypass, and the Sacramento River and numerous tributaries (70 FR 52488).

Adult steelhead immigration into Central Valley streams typically begins in August and continues into March (McEwan 2001; NOAA Fisheries 2004b). Steelhead immigration generally peaks during January and February (Moyle 2002). Optimal immigration and holding temperatures have been reported to range from 46°F to 52°F (CDFG 1991). Spawning usually begins during late-December and may extend through March, but also can range from November through April (CDFG 1986b). Optimal spawning temperatures have been reported to range from 39°F to 52°F (CDFG 1991). Unlike Chinook salmon, many steelhead do not die after spawning. Those that survive return to the ocean, and may spawn again in future years.

Optimal egg incubation temperatures have been reported to range from 48°F to 52°F (CDFG 1991). Preferred water temperatures for fry and juvenile steelhead rearing are reported to range from 45°F to 65°F (NOAA Fisheries 2002a). Each degree increase between 65°F and the upper lethal limit of 75°F reportedly becomes increasingly less suitable and thermally more stressful for the fish (Bovee 1978). Although the reported preferred water temperatures for fry and juvenile steelhead rearing range from 45°F to 65°F, most of the literature on steelhead smolting suggest water temperatures of 52°F (Adams *et al.* 1975; Myrick and Cech 2001; Rich 1987), or less than 55°F (USEPA 2003; McCullough *et al.* 2001; Wedemeyer *et al.* 1980; Zaugg and Wagner 1973) are required for successful smoltification to occur. The primary period of steelhead smolt emigration occurs from March through June (Castleberry *et al.* 1991).

Green Sturgeon

On April 5, 2005, NOAA Fisheries filed a proposed rule to list the southern population of North American green sturgeon as threatened under the ESA. On April 7, 2006, a final rule was issued and adopted, and the southern distinct population segment was listed as threatened. The final rule became effective April 7, 2006 (FR 17757).

Green sturgeon is an anadromous species, migrating from the ocean to freshwater to spawn. Adults of this species tend to be more marine-oriented than the more common white sturgeon. Nevertheless, spawning populations have been identified in the Sacramento River, and most spawning is believed to occur in the upper reaches of the Sacramento River as far north as Red Bluff (Moyle *et al.* 1995). Adults begin their inland migration in late-February (Moyle *et al.* 1995), and enter the Sacramento River between February and late-July (CDFG 2001). Spawning activities occur from March through July, with peak activity believed to occur between April and June (Moyle *et al.* 1995). Green sturgeon reportedly tolerate spawning water temperatures ranging from 50°F to 70°F (CDFG 2001). Small numbers of juvenile green sturgeon have been captured and identified each year from 1986 through 2001 in the Sacramento River at the Hamilton City Pumping Plant (RM 206) and at RBDD from 1995 through 2001 (NOAA Fisheries 2002b). Juvenile green sturgeon reportedly rear in their natal streams year-round (Moyle 2002). Within the Klamath River, juvenile green sturgeon emigration reportedly occurs from late May through July. Within the Trinity River, juvenile green sturgeon emigration reportedly occurs from early June through September. Although a green sturgeon sport fishery exists on the lower Feather River, the extent to which green sturgeon use the Feather River is still to be determined. Green sturgeon larvae are occasionally captured in salmon outmigrant traps, suggesting the lower Feather River may be a spawning area (Moyle 2002). However, NOAA Fisheries (NOAA Fisheries 2002b) reports that green sturgeon spawning in the Feather River is unsubstantiated.

In May – June 2007, 10 adult green sturgeon, ranging in size from 4 – 7 feet, were found battered and dead near the RBDD (Darling 2007a, Foott *in litt.* 2007, Bartoo *in litt.* 2007). Two of the dead sturgeon were identified as older gravid females. It is believed that the sturgeon were attempting to move downstream and got caught in the narrow opening underneath several of the gates at RBDD. The force of the water moving under these gates likely forced the sturgeon into the opening and pinned them there. Thirty-five green sturgeon were seen to have passed the dam. Currently, Reclamation is consulting with NOAA Fisheries and the Service on the RBDD Fish Passage Improvement Project.

Hardhead

Hardhead is a CDFG Species of Special Concern and a CALFED MSCS species; it was described above in the section "*Special-status Aquatic Species in Shasta Lake and Tributaries.*"

California Roach

California roach is a CDFG Species of Special Concern; it was described above in the section "*Special-status Aquatic Species in Shasta Lake and Tributaries.*"

Delta Smelt

The Service listed delta smelt as a "threatened" species under the ESA in March 1993 (CFR 58 12854), and critical habitat for delta smelt has been designated within the area. Delta smelt is also listed as a "threatened" species under the CESA. In addition to the Delta, delta smelt have been found in the Sacramento River as far upstream as the confluence with the Feather River near Verona (Moyle 2002; USFWS 1994). This species also occurs in the San Joaquin River, downstream of Vernalis (Reclamation and San Joaquin River Group Authority 1999). Delta smelt abundance appears to be reduced during years characterized by either unusually dry years with exceptionally low outflows (*e.g.*, 1987 through 1991) and unusually wet years with exceptionally high outflows (*e.g.*,1982 and 1986). Other factors thought to affect the abundance and distribution of delta smelt within the Bay-Delta estuary include entrainment in water diversions, changes in the zooplankton community resulting from introductions of non-native species, and potential effects of toxins.

Sacramento Splittail

The Service removed Sacramento splittail (*Pogonichthys macrolepidotus*) from the list of threatened species on September 22, 2003, and did not identify it as a candidate for listing under the ESA. Sacramento splittail is however, identified as a California species of special concern. Splittail occur in the Sacramento River, its major tributaries, the San Joaquin River and the Delta.

Sacramento splittail spawning can occur anytime between late February and early July, but peak spawning occurs in March and April (Moyle 2002). A gradual upstream migration begins in the winter months to forage and spawn, although some spawning activity has been observed in Suisun Marsh (Moyle 2002). During wet years, upstream migration is much more directed and fish tend to swim further upstream (Moyle 2002). Attraction flows are necessary to initiate travel onto floodplains where spawning occurs (Moyle *et al.* 2004). Spawning generally occurs in water with depths of 3 to 6 feet over submerged vegetation where eggs adhere to vegetation or debris until hatching (Moyle 2002; Wang 1986). Older fish are generally the first to spawn (Caywood 1974).

Eggs normally incubate for 3 to 7 days depending on water temperature (Moyle 2002). After hatching, splittail larvae remain in shallow weedy areas until water recedes, and they migrate downstream (Meng and Moyle 1995). The largest catches of Sacramento splittail larvae occurred in 1995, a wet year when outflow from inundated areas peaked during March and April (Meng and Matern 2001).

Juvenile Sacramento splittail prefer shallow-water habitat with emergent vegetation during rearing (Meng and Moyle 1995). Sommer *et al.* (2002) report juvenile splittail are more abundant in the Yolo Bypass floodplain in the shallowest areas of the wetland with emergent vegetation. Juvenile splittail are classified as benthic foragers (USFWS 1995c). Downstream movement of juvenile splittail appears to coincide with drainage from the floodplains between May and July (Caywood 1974; Meng and Moyle 1995; Sommer *et al.* 1997).

Sacramento splittail attain sexual maturity by the end of their second winter at a length of 180 to 200 mm (Daniels and Moyle 1983). Normal lifespan of Sacramento splittail ranges from 5 to 7 years (Caywood 1974; Meng and Moyle 1995). Adults can attain a length of over 300 mm (USFWS 1995c). Adults are normally found in relatively shallow (<12 ft.) water in brackish tidal sloughs, such as Suisun Marsh, but can also occur in freshwater areas with either tidal or riverine flows (Moyle *et al*. 2004). Splittail are also known to withstand very low dissolved oxygen levels (<1 mg O_2/l), a wide range of water temperatures (41.0°F to 75.2°F) and salinities of 6 – 10 ppt (Moyle *et al*. 2004).

Floodplain inundation during March and April appears to be the primary factor contributing to splittail abundance. Sommer (Sommer Unpublished Work 2003) speculates that during dry years, the frequency and duration of floodplain inundation is not sufficient to support high levels of foraging, spawning and rearing. Moyle (Moyle *et al*. 2004) reports that moderate to strong year classes of splittail develop when floodplains are inundated for 6 to 10 weeks between late February and late April. Reportedly, when floodplains are inundated for less than a month, strong year classes are not produced (Sommer *et al*. 1997).

Sommer *et al.* (1997) discuss the resiliency of splittail populations and suggest that because of their relatively long life span, high reproductive capacity and broad environmental tolerances, splittail populations have the ability to recover rapidly even after several years of drought conditions. This suggests that frequent floodplain inundations are not necessary to support a healthy population. Moyle (Moyle *et al*. 2004) reports that the ability of at least a few splittail to reproduce even under the worst flow conditions insures that the population will persist indefinitely, despite downward trends in total population size during periods of drought.

Longfin Smelt

Longfin smelt are pelagic, estuarine fish which range from Monterey Bay northward to Hinchinbrook Island, Prince William Sound Alaska. In California, the only collections made in the 1990s have been from the Klamath River and San Francisco Bay (CDFG 2007c).

Maturity is reached toward the end of their second year. As they mature in the fall, adults found throughout San Francisco Bay migrate to brackish or freshwater in Suisun Bay, Montezuma Slough, and the lower reaches of the Sacramento and San Joaquin Rivers. Spawning probably takes place in freshwater. In April and May, juveniles are believed to migrate downstream to San Pablo Bay; juvenile longfin smelt are collected throughout the Bay during the late spring, summer and fall, and occasionally venture into the Gulf of the Farallons. Juveniles tend to inhabit the middle and lower portions of the water column (CDFG 2007c).

A relationship between freshwater outflow and longfin smelt abundance has been identified. The overall effect of high freshwater outflow appears to be an increase in the amount and quality of nursery habitat (i.e. creation of brackish water habitat in San Pablo Bay) and a broader dispersal of young-of-the-year fish, potentially increasing feeding opportunities and reducing density-dependent mortality. Differences in overall dispersal of young-of-the-year fish longfin smelt are not readily detectable with the data presented, yet increased use of San Pablo Bay was noted in both high abundance years. Alternately, low freshwater outflows during the winters of 1987-1992 are believed to be the main reason for the decline in longfin smelt during the same period (CDFG 2007c).

Longfin smelt were once one of the most abundant open-water fishes in the Bay-Delta and a central component of the food web that sustained other commercially important species. Throughout the 2000s, the Bay-Delta longfin smelt population has been just 3 percent of levels measured less than 20 years ago; for the past 4 years, longfin smelt numbers have been at record lows (CDFG 2007c). Fall midwater trawl surveys show that the longfin smelt abundance index in 2007 was at its lowest since the surveys began in 1967 (CDFG 2007e). Longfin smelt have declined due to many of the same degraded environmental conditions in the Bay-Delta Estuary that are believed to have caused the collapse of the delta smelt: reduced freshwater inflow to the estuary as a result of massive water diversions; loss of fish at agricultural, urban, and industrial water diversions; direct and indirect impacts of nonnative species on food supply and habitat; and lethal and sub-lethal effects of pesticides and toxic chemicals (Armor *et al.* 2005; Herbold *et al.* 2006; Sommer *et al.* 2007; The Bay Institute *et al.* 2007a; USFWS 2004a). On August 8, 2007, the Center for Biological Diversity, along with The Bay Institute, and Natural Resources Defense Council, petitioned for State and Federal endangered species protection for the longfin smelt (The Bay Institute *et al.* 2007a). The Service is currently reviewing the petition to see if the listing of longfin smelt is warranted.

<u>Special-status Bird Species along the Sacramento River</u>

Western Yellow-Billed Cuckoo

Historically, the western yellow-billed cuckoo (*Coccyzus americanus occidentalis*) was a common breeding species in riparian habitat throughout much of lowland California (Grinnell

1915; Grinnell and Miller 1944). By 1944 cuckoos were no longer present in extensive areas where they were once found "because of removal widely of essential habitat conditions" (Grinnell and Miller 1944).

In California, breeding populations of greater than five pairs which persist every year in California are currently limited to the Sacramento River from Red Bluff to Colusa and the South Fork Kern River from Isabella Reservoir to Canebrake Ecological Reserve (Laymon and Halterman 1987). A statewide survey of yellow-billed cuckoos in California conducted during 1986 and 1987 found a total of 30-33 pairs and 31 unmated males at nine localities (Laymon and Halterman 1989). The majority of the cuckoos were concentrated along the upper Sacramento River from Red Bluff to Colusa (18 pairs and 19 unmated males) and at the South Fork Kern River (7 pairs and 3 unmated males). More recent surveys on the Sacramento River from 1987 - 1990 have shown a fluctuating population of 23 - 35 pairs (Halterman 1991). Continuous surveys on the South Fork Kern River from 1985 - 1996 have shown a population that varied from a low of 2 pairs in 1990 to a high of 24 pairs in 1992 (Laymon *et al*. 1997). These two sites are the only localities in California that sustain breeding populations of yellow-billed cuckoos (Laymon 1998).

On the Sacramento River, from 1987 to 1990, the extent of habitat in 8 km river stretches was used as a measure of habitat fragmentation. This was the second most important variable in determining the presence of pairs ($r^2=0.16$, $p<0.005$), unmated males ($r^2=0.10$, $p<0.005$), and all cuckoos encountered during this four-year study ($r^2=0.17$, $p<0.005$) (Halterman 1991). Patch size is a very important landscape feature for yellow-billed cuckoos. In California, away from the Colorado River, cuckoos occupied 9.5 percent of 21 sites 20 to 40 ha in extent, 58.8 percent of 17 sites 41 to 80 ha in extent, and 100 percent of 7 sites greater than 80 ha in extent. The trend towards increased occupancy with increased patch size is significant ($t = 3.63$, $p<0.001$) (Laymon and Halterman 1989). On the Sacramento River, from 1987 to 1990, the extent of patch size was the most important variable in determining occupancy for pairs ($r^2=0.25$, $p<0.005$), unmated males ($r^2=0.18$, $p<0.005$), and all cuckoos encountered ($r^2=0.27$, $p<0.005$) (Halterman 1991). The best habitats for nesting are therefore at large sites with high canopy cover and foliage volume, and moderately large and tall trees. Sites capable of producing this type of habitat should receive the highest priority when restoration plans are developed.

The degradation of cottonwood-willow riparian habitat as a result of the invasion by salt cedar (*tamarisk sp*.) and giant reed (*Arundo donax*) is a major problem over much of the cuckoo's range (Laymon 1998). Along the Sacramento River, domestic fig and black walnut have also become dominant tree species, while probably offering little to cuckoos for either nesting or foraging. All of these invasive exotics are poor at providing foraging opportunities for cuckoos because the cuckoos preferred prey are not found on these substrates. These exotics also do not offer good nest sites (Laymon 1998).

The western yellow-billed cuckoo is listed as a California Endangered Species, a Federal candidate species, a U.S. Forest Service Region 5 Sensitive Species, and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions contribute to the recovery of the western yellow-billed cuckoo by implementing some of the actions deemed necessary to recovery of the species' populations. Conservation measures for this species are identified in Appendix D of this report.

California Yellow Warbler

The California yellow warbler was described previously in the section *Migratory and Special-Status Bird Species near Shasta Lake***.** The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions contribute to the recovery of the California yellow warbler by implementing some of the actions deemed necessary to recovery of the species' populations. Species-specific conservation measures are provided in Appendix D of this report.

Yellow-Breasted Chat

The yellow-breasted chat was described previously in the section *Migratory and Special-Status Bird Species near Shasta Lake*. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions must maintain the status of the yellow-breasted chat and that any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures for the species are identified in Appendix D of this report.

Tricolored Blackbird

Tricolored blackbirds (*Agelaius tricolor*) arrive at their breeding grounds in the Sacramento and San Joaquin Valleys in mid-March through mid-July (Hamilton 2004). In spring large flocks as are associated with dairies and ripening grain heads. Tricolor blackbird nesting colonies require open water within 500 m and irrigated pastures, dry rangeland, or other foraging habitat within a few kilometers (Hamilton 2004). Dominant nest substrates include cattails, bulrushes, Himalaya blackberry, and agricultural silage (Hamilton 2004). The tricolored blackbird is a California species of special concern and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions must maintain the status of the tricolored blackbird and that any adverse effects on the species must be fully offset through implementation of actions beneficial to the species. Conservation measures for the species are identified in Appendix D of this report.

Bank Swallow

The bank swallow (*Riparia riparia)* occurs as a breeding species in California in a hundred or so widely distributed nesting colonies in alluvial soils along rivers, streams, lakes, and ocean coasts (Garrison 1998). The bird is largely found in riparian ecosystems, particularly rivers in the larger lowland valleys of northern California. Nesting colonies are located in vertical banks or bluffs in friable soils, and these colonies can support dozens to thousands of nesting birds (Garrison 1998). Bank swallows arrive on their breeding grounds in California beginning in late March and early April, and the bulk of breeding birds arrive in late April and early May. Bank swallows vacate their breeding grounds as soon as juveniles begin dispersing from the colonies around late June and early July (Garrison 1998). Nesting habitat is particularly prone to erosion, and habitat in some areas such as the Sacramento and Feather rivers is threatened with loss by flood control and bank protection projects (Garrison 1998). The bank swallow is a California threatened species and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions contribute to the recovery of the bank swallow by implementing some of the actions deemed necessary to recovery of the species' populations. Species-specific conservation measures are provided in Appendix D of this report.

Swainson's Hawk

In California, breeding populations of Swainson's hawk (*Buteo swansoni*) occur in desert, shrubsteppe, grassland and agricultural habitats, but the overwhelming majority of sites are in two disjunct populations in the Great Basin and Central Valley (Woodbridge 1998). In the Central Valley, nest sites are strongly associated with riparian forest vegetation (Woodbridge 1998). The primary habitat requisite provided by riparian systems is nesting substrate, typically large trees (Woodbridge 1998). Swainson's hawk is a California threatened species and a CALFED MSCS species. The CALFED Programmatic EIS/EIR and ROD (CALFED 2000a,b) require that all CALFED actions contribute to the recovery of Swainson's hawk by implementing some of the actions deemed necessary to recovery of the species' populations. Species-specific conservation measures are provided in Appendix D of this report.

APPENDIX F

Draft Habitat Evaluation Procedures (HEP) Report

for the Shasta Lake Water Resources Investigation

Sacramento Fish and Wildlife Office

U.S. Fish and Wildlife Service

The HEP analysis has not been completed yet. The HEP report will be placed here in Appendix F upon completion.