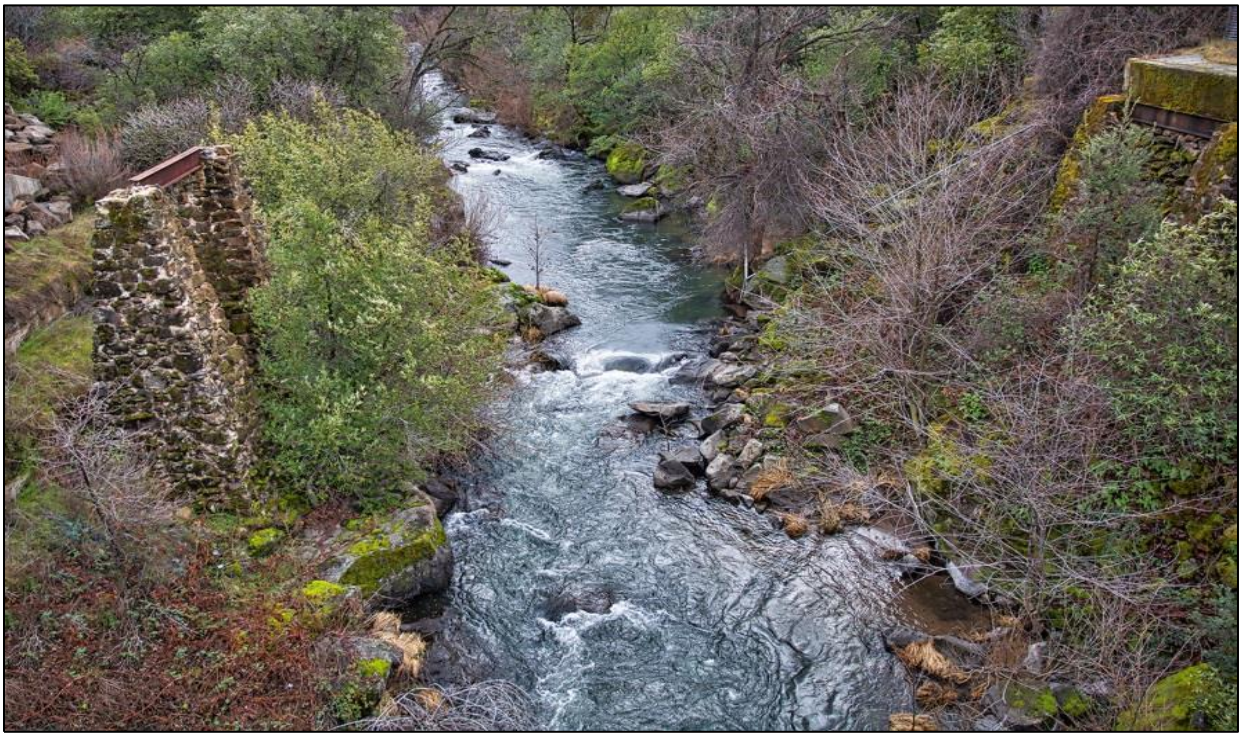
Summary of Actions to Jumpstart the Reintroduction of Sacramento River Winter-run Chinook Salmon to Battle Creek, 2017 – 2018



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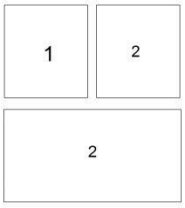

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TABLE OF CONTENTS

Document Overview **1**

Background **1**

Sacramento River Winter-run Chinook Salmon 1

Spawning Distribution 1

Status 2

Winter Chinook Salmon Conservation Hatchery 3

Severe Drought 4

Hatchery Role in Mitigating the Effects of Drought 4

Effects of Drought on Winter Chinook Abundance 4

Using captive broodstock to Improve Population Resiliency 5

Jumpstarting the Battle Creek SRWCS Reintroduction Process **6**

Spawning 6

Incubation and Rearing 7

Marking and Tagging 8

Fish Health 10

Fine-scale Imprinting 10

Juvenile Releases 11

Next Steps **15**

LITERATURE CITED **16**

ATTACHMENT 1.—Fish Health Inspection Report for captive winter Chinook Salmon broodstock, and their progeny, contributing to the brood year 2017 release group. **39**

TABLES

TABLE 1.—Record of broodstock pairings and egg production for Sacramento River Winter Chinook captive broodstock spawned at the Livingston Stone National Fish Hatchery in 2017 18

TABLE 2.—Relevant early life history dates and count summary of brood year 2017 winter Chinook Salmon captive broodstock progeny produced at the Livingston Stone National Fish Hatchery and transferred for rearing to the Coleman National Fish Hatchery (CNFH). 35

TABLE 3.—Estimated rates of mark-tag retention and numbers (in parenthesis) of winter Chinook released with various combinations of marks and tags, based on sampling conducted >21-days after marking and tagging 36

TABLE 4.—Summary of release data for brood year 2017 winter Chinook Salmon captive broodstock progeny. 36

FIGURES

FIGURE 1.—Daily water temperature profile for the Coleman NFH from October 1 to November 30, 2017 37

FIGURE 2.—Measured rate of flow, cubic feet per second, on Battle Creek near the Coleman National Fish Hatchery and on the Sacramento River at Bend Bridge from March 1 to May 2, 2018 (....37

FIGURE 3.—Map of the North Fork Battle Creek section containing the three proposed winter Chinook Salmon captive progeny release sites. 38

Document Overview

This document describes actions taken during 2017 – 2018 to initiate the reintroduction of Sacramento River winter-run Chinook Salmon *Oncorhynchus tshawytscha* (hereafter referred as SRWCS or winter Chinook Salmon) to Battle Creek using the progeny of captive broodstock from the Livingston Stone National Fish Hatchery (LSNFH). Winter Chinook Salmon are listed as endangered under state and federal endangered species acts. Lack of spatial structure and diversity are principle threats to SRWCS. Currently, SRWCS exist as a single population, which is restricted to spawn in the Sacramento River downstream of Shasta Dam – an area completely outside of the species' geographical range of historic spawning. The persistence of SRWCS is completely dependent on receiving managed supplies of cold water from Shasta Lake, leaving it extremely vulnerable to impacts from catastrophic events and climate change. The U.S. Fish and Wildlife Service (USFWS) operate a conservation hatchery for SRWCS at the LSNFH, located at the base of Shasta Dam. The Winter Chinook Salmon Integrated-Recovery Conservation Hatchery consists of two programs, a captive broodstock program and a supplementation program. Together, these two programs are intended to reduce the risk of extinction, increase abundance, preserve genetic diversity, and contribute to the recovery of the Sacramento River winter Chinook Salmon Evolutionarily Significant Unit (SRWCS ESU).

Battle Creek is an east-side tributary of the Sacramento River located in Shasta and Tehama Counties, California. A population of SRWCS that historically spawned in Battle Creek was extirpated because of habitat changes resulting from hydropower development, dating back to the early 1900s. An ongoing, large-scale habitat restoration project aims to restore fish habitats in Battle Creek by providing conditions suitable to once again support a population of SRWCS. In preparation for the completion of restoration actions, a comprehensive plan (Reintroduction Plan) to reintroduce SRWCS to Battle Creek was collaboratively developed by a multi-stakeholder team. The USFWS has been identified as lead agency for implementing the Reintroduction Plan, which is currently on hold pending receipt of funding.

As a result of a prolonged and severe drought in California's Central Valley, natural production of SRWCS in the Sacramento River was severely diminished during 2014 and 2015, increasing the risk of imminent extinction. In response, a multi-agency decision was made to lessen the risk of extinction and improve population resiliency by spawning captively-reared SRWCS and releasing their progeny into Battle Creek, thereby accelerating the timeline of reintroducing SRWCS to that tributary (USFWS 2017). This reintroduction strategy differs from that proposed in the Reintroduction Plan. This document describes the strategies that were used to "Jumpstart" the reintroduction of SRWCS to Battle Creek and describes the issues, considerations, and rationale for choosing specific reintroduction strategies.

Background

Sacramento River Winter-run Chinook Salmon

Spawning Distribution

Winter Chinook Salmon are unique amongst the four races of Chinook Salmon of California's Central Valley in that they spawn during the summer months, from mid-April to mid-August, when air temperatures typically reach their annual maxima. Historic spawning locations of SRWCS included the cold headwater reaches of rivers and streams on the flanks of Mt. Shasta and Lassen Peak - areas where a reliable supply of cold water from snow melt and underground

springs provided suitable temperatures throughout the summer months. Native SRWCS spawning areas on the slopes of Mt. Shasta include the watersheds of the Little Sacramento, McCloud, and Pit rivers; all of these areas have been inaccessible to SRWCS since the construction of Shasta and Keswick dams in the early 1940s. Historic SRWCS spawning areas on the slope of Lassen Peak were limited to the Battle Creek watershed. Naturally reproducing SRWCS in Battle Creek were likely impacted and locally extirpated as a result of hydropower development dating back to the early 1900s, which degraded and blocked access to suitable spawning habitats. Currently, the SRWCS ESU is comprised of a single population that spawns in the Sacramento River downstream of Keswick Dam, an area that is completely outside of the historic range of SRWCS spawning. Nonetheless, winter Chinook Salmon have persisted downstream of Keswick Dam as a result of cold water releases from Shasta Dam, which are managed by the Bureau of Reclamation to provide temperatures suitable for spawning, egg incubation, and early rearing.

Battle Creek is an east-side tributary to the Sacramento River downstream of Shasta Dam. Battle Creek is unique because its cold water springs and high year-round base flows provide the only historic spawning habitats for SRWCS downstream of Shasta Dam. In 1999 agencies and stakeholders struck an agreement to restore fish habitats in Battle Creek, which was formalized with the signing of a Memorandum of Understanding leading to implementation of the Battle Creek Salmon and Steelhead Restoration Project (BCRP). Habitat improvement projects associated with the BCRP are currently underway and scheduled to be completed in 2023. When completed, the BCRP will restore and provide access to an additional 48 miles of habitat for salmon and steelhead, including the only potentially suitable historic habitat for SRWCS spawning within the range of anadromy.

Status

Sacramento River winter Chinook Salmon were listed as a federally threatened species in 1989 (54 FR 32085: August 4, 1989) and reclassified as endangered in 1994 (59 FR 440: January 4, 1994). A subsequent proposal (69 FR 33102: June 14, 2004) to reclassify SRWCS as a threatened species in 2004 was not adopted and SRWCS were reaffirmed as an endangered species in 2005 (70 FR 37160: June 28, 2005) and through a status review in 2011 (76 FR 50447). Winter Chinook Salmon have also been listed as an endangered species under the California Endangered Species Act since 1989. The SRWCS ESU includes fish spawning naturally in the Sacramento River and its tributaries and those that are part of the conservation hatchery operated by the USFWS (70 FR 37160: June 28, 2005). Recently, SRWCS have been declared as one of eight "Species in the Spotlight" by the National Oceanic and Atmospheric Administration (NOAA), the parent agency of the National Marine Fisheries Service (NMFS; https://www.fisheries.noaa.gov/topic/endangered-species-conservation/species-spotlight). The Species in the Spotlight designation is intended to focus attention and recovery efforts on species that are considered to be at a high risk of extinction in the near future. Principal population characteristics that contribute to the endangered status of SRWCS are lack of both diversity and spatial structure. The recovery strategy developed by the NMFS for Central Valley Chinook Salmon and steelhead is "to secure all extant populations and to reintroduce populations into

historic habitat such that each salmonid diversity group[1] in the Central Valley supports viable populations" (NMFS 2014). The term diversity group refers to salmonid ecoregions, which are delineated by climatological, hydrological, and geological characteristics. Historic habitats with the potential to support SRWCS include Battle Creek and upstream of Shasta Dam.

Winter Chinook Salmon Conservation Hatchery

Since 1989, the USFWS has operated a conservation hatchery for SRWCS, which is located on the Sacramento River at the base of Shasta Dam. The goal of the SRWCS conservation hatchery is to prevent extinction, conserve diversity, and increase abundance, thereby contributing to the preservation, stability, and recovery of SRWCS ESU.

The SRWCS Conservation Hatchery consists of two interrelated programs: the Integrated-Recovery Supplementation Program, hereafter referred as the "Supplementation Program", and the Captive Broodstock Program. The Supplementation Program is operated to increase abundance and conserve genetic resources of the at-risk SRWCS population. The Captive Broodstock Program maintains a source of broodstock in a safe and secure captive environment, providing an added measure of insurance against catastrophic year-class failures. Together, the Supplementation Program and Captive Broodstock Program are intended to increase resiliency and promote recovery of the endangered SRWCS ESU.

A complementary goal of the SRWCS Conservation Hatchery is to provide a source of fish for re-establishment of locally-extirpated natural spawning populations in Battle Creek and upstream of Shasta Dam. This hatchery role is consistent with the recovery strategy put forth in the NMFS Recovery Plan (2014), which is "to secure all extant populations and to reintroduce populations into historic habitat such that each salmonid diversity group in the Central Valley supports viable populations". The NMFS has identified reintroduction of SRWCS to Battle Creek and upstream of Shasta Dam as key recovery actions to address the threats facing SRWCS. Successful introductions into these historic spawning habitats would reduce the likelihood of extinction and contribute to the recovery goals (NMFS 2014).

Efforts to reintroduce SRWCS upstream of Shasta Dam and to Battle Creek will rely, to some extent, on the SRWCS Conservation Hatchery as a source of fish. The SRWCS Conservation Hatchery has been identified as an integral component of the plan to reintroduce SRWCS to Battle Creek (McConnaha et al. 2016). Implementation of the Battle Creek Winter-Run Reintroduction Plan (Reintroduction Plan) currently has not been funded and, as a result, the timeline for implementing the program has yet to be established. Preliminary feasibility studies for the effort to reintroduce SRWCS to historic spawning habitats upstream of Shasta Dam are currently in progress, but a detailed reintroduction strategy has not been developed. This project, however, will also likely rely on the SRWCS Conservation Hatchery and associated fish trapping facilities as a source of fish for both preliminary studies and project implementation.

[1] The term diversity group refers to salmonid ecoregions, which are delineated by climatological, hydrological, and geological characteristics (NMFS 2014).

Severe Drought

The period from 2012 – 2015 was the driest four-year span in California since record keeping began in the late 1800s (PPIC; http://www.ppic.org/publication/what-if-californias-drought-continues). This period of record low precipitation was accompanied by exceptionally warm temperatures, which exacerbated the effects of drought by reducing an already diminished snowpack and increased societal demands for water. Cumulative effects of severe drought and exceptionally warm temperatures depleted the state's reservoirs, which forced curtailing of water deliveries. The largest reservoir in the state, Lake Shasta, became exhausted of its cold water pool in the late summer of 2014 and 2015, thereby impeding the ability to maintain downstream temperatures within the range required for successful natural spawning of SRWCS. As a result, reproductive success of naturally-spawning SRWCS was severely diminished during two consecutive years. Estimates of egg-to-fry survival, which typically average about 25% for naturally spawning SRWCS, were reduced to only 5.9% and 4.5% during 2014 and 2015, respectively (Bill Poytress, pers. comm., USFWS, Red Bluff, CA). The scant few SRWCS juveniles that were produced were also challenged during their emigration to the ocean by unfavorable conditions of low flows and high temperatures in the Sacramento River and the Bay-Delta, further reducing expectations of survival for SRWCS from these two year classes. Cumulative effects of these events resulted in the near-complete failure of two consecutive years of naturally spawning SRWCS.

Hatchery Role in Mitigating the Effects of Drought

With pre-season temperature modeling predicting that the Sacramento River would likely exceed the thermal limit of successful natural SRWCS spawning during 2014 and 2015, the USFWS, NMFS, and the California Department of Fish and Wildlife, referred to collectively as the Fish Management Agencies, anticipated the potential of a near-complete failure of natural production. In response, the Fish Management Agencies enacted emergency measures to temporarily expand the size of the SRWCS Conservation Hatchery. Included in this emergency action was the decision to temporarily expand the size of the Supplementation Program. Broodstock collection goals for the Supplementation Program, which are typically set at 60 female and 60 male, were revised to collect and retain as many SRWCS as could be captured and accommodated at LSNFH as hatchery broodstock. To facilitate this, the hatchery retained both hatchery- and natural-origin SRWCS; this is a deviation from the standard program protocol that use only naturally-produced fish as hatchery brood. As a result of these changes, broodstock collection at the LSNFH was substantially increased in 2014 and 2015 and total hatchery production of SRWCS juveniles reached levels two- and three-fold larger than standard production levels.

Effects of Drought on Winter Chinook Abundance

Demographic effects of drought, which may persist for multiple generations, highlight the vulnerable status of the SRWCS ESU, which consists of only one population entirely dependent on releases of cold water from Shasta Lake. Viability of an ESU that is represented by a single population is at increased risk of extinction. A single catastrophic event lasting four or more years could extirpate the entire SRWCS ESU (Lindley et al. 2007). Furthermore, an ESU comprised of only one population is inherently vulnerable to limitations of genetic and life history diversity. Genetic variation of SRWCS substantially reduced, compared to other runs of salmon in the Central Valley and across the Pacific Coast, perhaps as a result of past bottlenecks and genetic drift (Banks et al. 2000). Because genetic variation provides the mechanism of

adaptation through natural selection, further reductions of genetic variation are a primary concern for the conservation of SRWCS, as they may affect the ability of the population to adapt to changing environments.

Results of spawner escapement surveys support expectations of the Fish Management Agencies that the drought had resulted in the near-complete failure of SRWCS natural production during 2014 and 2015. Spawner escapement surveys estimated 975 SRWCS returned to the upper Sacramento River in 2017 (California Department of Fish and Wildlife Grandtab - https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=84381&inline), marking the second-lowest annual spawner escapement estimate in the recent 20 year period. An estimated 85% of the SRWCS spawners in 2017 were hatchery-origin fish from LSNFH (K. Offill, USFWS, Red Bluff, CA, unpublished data), evidence that emergency measures enacted at the LSNFH were successful at avoiding a complete year-class failure. Few natural-origin adults returning and high percent of hatchery-origin spawners suggests reproductive success of naturally spawning SRWCS in 2014 was greatly diminished and increased propagation efforts enacted at the LSNFH substantially benefitted the abundance of spawners in 2017. Spawning area surveys of 2018 are currently underway at the time of drafting this document, and an estimate of total spawners is not yet available. However, preliminary data from daily surveys again supports expectations of severely limited natural production during 2015, with a low abundance of natural origin spawners and a high proportion of hatchery-origin fish (Kevin Niemela, USFWS, Red Bluff, CA, unpublished data).

Using Captive Broodstock to Improve Population Resiliency

With evidence that the drought had severely reduced natural reproductive success of the SRWCS for two consecutive year classes, and recognizing the potential conservation values of the captive broodstock at the LSNFH, the Fish Management Agencies made the decision to spawn captive broodstock and use their progeny to initiate reintroduction of SRWCS into historic spawning habitats of Battle Creek[2]. This method of reintroducing winter Chinook Salmon to Battle Creek differs from the recommendations from the Reintroduction Plan, which calls for using the progeny of wild-caught broodstock. Since this strategy of reintroducing SRWCS to Battle Creek differs from the recommended strategy contained in the Reintroduction Plan, the project was called the Winter Chinook Salmon "Jumpstart" Project. The Jumpstart Project is intended to transition into implementation of the Reintroduction Plan when funding becomes available.

The Jumpstart Project confers a key benefit of quickly increasing spatial structure of the SRWCS ESU, which is a primary need for the conservation of SRWCS. It also provides an opportunity to learn about the suitability of Battle Creek for a secondary population of SRWCS while

[2] Alternative options that were considered for using the captive broodstock to derive a conservation benefit included (1) increasing the size of the Supplementation Program in Sacramento River; and 2) contributing to multi-agency efforts to reintroduce SRWCS upstream of Shasta Dam. These projects were evaluated for their feasibility and compared to the Battle Creek reintroduction project with regards to their benefits and drawbacks (USFWS 2017). Based on this evaluation, these projects did not advance past this initial analysis and did not receive any progeny of the SRWCS captive broodstock from the 2017 spawning year, but may be reconsidered in future years.

presenting negligible risks of detrimental effects to the existing SRWCS population in the mainstem Sacramento River. The primary risk of this conservation action is that captive broodstock progeny may not be successful at developing a SRWCS population in Battle Creek, potentially failing to take full advantage of the conservation potential contained within the captive broodstock and thereby failing to achieve the conservation benefits envisioned for this valuable resource.

Jumpstarting the Battle Creek SRWCS Reintroduction Process

The remainder of this document will discuss actions that were taken during the winter Chinook Salmon hatchery production cycle of 2017 – 2018 to Jumpstart the reintroduction of Winter Chinook Salmon to Battle Creek. The sequence of information in this section follows the timeline of management events associated with the hatchery production cycle, including: spawning, incubation and rearing, marking and tagging, assessment of fish health, imprinting, and juvenile releases. Each of these sections has been formatted to first identify the management actions that were taken (shown in **bold**) to Jumpstart the reintroduction of winter Chinook Salmon to Battle Creek, followed by an explanation of the rationale behind those actions (shown in *italic*s). The intent of structuring the document in this manner is to allow the reader to quickly identify specific management actions that were taken and then, if necessary, to investigate the underlying logic/rationale.

Spawning

Management Action:

Spawning of captive broodstock at the LSNFH occurred from July 25 to September 19, 2017, corresponding to timing of sexual maturation. To promote synchronous maturation, male and female captive broodstock were combined in a common rearing unit during late stages of rearing. Luteinizing Hormone-releasing Hormone analogue (LH-RHa) implants were administered to accelerate the maturation of ten females. Four hundred seventy-seven different family group combinations were created by spawning 244 female captive broodstock with 168 male broodstock of the following origins: captive broodstock (BY14: n=41, BY15: n=115), wild-caught broodstock remaining from the Supplementation Program (n=10), and cryopreserved semen (RY17: n=2; Table 1).

Rationale:

Spawning of captive broodstock in 2017 (July 25 – September 19) was later than that of wild-caught SRWCS broodstock, including fish of hatchery and natural origin spawned in the Supplementation Program (April 24 – August 7). Delayed spawning of captive broodstock is attributed to later timing of sexual maturation. Winter Chinook Salmon captive broodstock at LSNFH typically exhibit seasonally delayed maturation relative to natural spawning winter Chinook Salmon (Kevin Niemela, USFWS, Red Bluff, CA, unpublished data). Similar observations of delayed sexual maturation have been previously observed within other salmon captive brood programs (Patterson et al. 2004; Berejikian et al. 1997). Because spawning of captive broodstock was delayed relative to that of broodstock collected from the wild, timing of successive juvenile life history events (e.g., eye-up, hatching, button-up) and associated management activities (e.g., marking and tagging, target release size) were also delayed relative to the progeny of wild-caught broodstock used in the Supplementation Program.

A partial factorial (2x2) mating design was used to increase the effective population size, as compared to single pair matings. Partial factorial matings increase effective population size by better equalizing the number of progeny produced per parent. To conduct partial factorial matings, eggs from each female were split into two groups and each group of eggs was fertilized using the milt from a different male. Ideally, each male would have been used to fertilize two groups of eggs, equivalent to the total egg production of one female; however, because the number of females exceeded the number of males, each male was used to fertilize an average of 3.0 groups of eggs (range 1 – 7). To reduce likelihood of mating closely related individuals, pairings of captive broodstock were informed by an assessment of genetic relatedness. Due to reduced viability associated with fertilizing eggs with cryopreserved semen, a prioritization scheme favored using semen from live males.

All female captive broodstock spawned were age-3 (i.e., brood year 2014). Relative to the number of female captive broodstock spawners, a reduced number of age-3 males were available due to mortality caused by maturation as age-2 "jacks" and a concurrent outbreak of bacterial gill disease (Attachment 2). A substantial portion (73.7%) of captive broodstock males were jacks (i.e., brood year 2015). A total of 288,134 eggs were hand counted from collections across 19 spawning dates occurring July 25 through September 19. Eggs from an additional three females were collected, but not counted due to the condition known as "soft shell" that prevented physical handling. Average fecundity of counted captive broodstock was 1,196 eggs/female (range: 186 – 3,008).

Incubation and Rearing

Management Action:

Embryos were initially incubated in vertical stacks of fiberglass incubator trays (Heath Incubation Trays) at LSNFH. Survival to eyed stage was 86.6%, which is within the range previously observed for SRWCS captive broodstock spawned with wild-caught broodstock at LSNFH (BY2001 – BY2006; range: 39.2% – 99.3%, avg. = 81.3%, SD = 21.9; Table 1). However, this rate of survival is less than the average (93.6%, range: 87.4% – 97.2%, SD = 2.8) observed for pairings of wild-caught broodstock spawned in the Supplementation Program since 1998.

Captive broodstock progeny were transferred to Coleman National Fish Hatchery (CNFH) between October 11 and November 2, 2017. First fourteen egg takes were transferred to the CNFH as button-up fry and final five egg takes were transferred to CNFH as eyed eggs (Table 2).

At the button-up stage, juvenile SRWCS were moved from incubator trays into fiberglass tanks (16' x 3'4") to initiate feeding. Throughout period of early rearing, fry from 19 egg takes were aggregated into seven pooled groups, called 'lots'. Lots ranged in size from approximately 23,000 to 38,000. Lots were transferred to outdoor 8' x 80' raceways between December 12, 2017 and February 23, 2018, where they were reared until release.

Rationale:
To improve imprinting to Battle Creek, captive broodstock progeny were transferred from LSNFH to CNFH at the earliest possible life stage - either as eyed eggs or as button-up fry - dependent on timeline of embryo development relative to water temperature suitability at CNFH. CNFH is located on Battle Creek; therefore, juvenile salmon that are transferred to CNFH during their early life history will be exposed to distinctive chemical cues of the watershed to promote imprinting and homing to Battle Creek. Embryos from five egg takes were transferred to CNFH from 3 – 16 days prior to hatch and button-up fry from 14 egg takes were transferred to CNFH from 25 – 40 days after hatch. A temperature of ≤60°F (daily maximum) was used as a threshold to indicate suitable temperatures for transferring fry to CNFH; this threshold was met on October 1, triggering the transfer of SRWCS to the CNFH soon thereafter (Figure 1). A temperature of ≤56°F (daily maximum) was the threshold used to indicate suitable temperatures for transferring SRWCS eggs to CNFH; this threshold was met on October 9, triggering the transfer of SRWCS to CNFH soon thereafter.

To facilitate ponding within the 8'x 80' raceways, juvenile SRWCS from 19 egg takes were aggregated into seven pooled groups at CNFH. To promote a uniform size distribution and improve feeding, growth, and survival of pooled groups, it was necessary to manipulate (i.e., accelerate or retard) the growth of several egg lots prior to combining them in a raceway.

Marking and Tagging

Management Action:
Marking and tagging were conducted from January 23 to February 26, 2018, by a contracted crew from the Pacific States Marine Fishery Commission. Juvenile SRWCS were first processed through the automated Marking and Tagging System trailer (MATS: Northwest Marine Technology, Shaw Island, WA), which applied an adipose fin clip and coded-wire tag (CWT) to each fish. Each of the seven raceways received a uniquely numbered CWT. After a raceway of juvenile fish was completely processed in the MATS trailer, the lot was again processed through another trailer, where the left pelvic fin was manually removed from each fish. The rate of ventral fin clipping was approximately 250 fish/person/hour, which includes time for project preparations and shut-down. Approximately four days were required to completely process each lot of salmon through both tagging trailers (e.g., one day for CWT and removal of adipose fin plus three days for removal of pelvic fin). Total cost of tagging is estimated to be approximately $73,000.

Effectiveness of marks and tags was assessed for at least 21-days after the final tag date. Assessments indicated a high level of mark-tag effectiveness (Table 3). Overall retention rates of adipose-fin clip, CWT, and left pelvic-fin clip averaged 99.3% (range: 98.5% – 100.0%, SD = 0.5) among the seven CWT groups. Increased rates of direct mortality from marking and tagging were not apparent, however, see Fish Health section, below.

Rationale:
Ability to identify Jumpstart SRWCS after they are released into the wild has important implications for their monitoring and management throughout their geographical range. Of particular importance is to distinguish introduced Jumpstart SRWCS from late-fall Chinook Salmon at CNFH during their adult migration into Battle Creek. Migration timing of SRWCS

overlaps considerably with that of late-fall Chinook Salmon, and adults of both stocks coincide at the hatchery during their spawning migration. During a typical year, several thousand hatchery-origin late-fall Chinook return to the CNFH and must be quickly distinguishable from Jumpstart SRWCS so that the hatchery can continue late-fall Chinook Salmon spawning operations while avoiding unnecessary handling and associated impacts to winter Chinook Salmon. All late-fall Chinook Salmon produced at the CNFH are coded-wire tagged and marked with an adipose-fin clip, so a different marking and tagging strategy was needed for Jumpstart SRWCS. It is also important that introduced Jumpstart SRWCS be distinguishable from naturally produced spring Chinook Salmon in Battle Creek, which do not receive a mark or tag. Lastly, monitoring of California ocean commercial and recreational fisheries and inland sport fishery also rely on monitoring programs, which are based on adipose fin clips and coded wire tags. Any marking and tagging strategy for introduced Jumpstart SRWCS that doesn't include, at minimum, an adipose-fin clip and coded-wire tag would not be detected by existing harvest monitoring programs.

Alternative strategies for marking and tagging SRWCS were considered during development of the Reintroduction Plan (McConnaha et al. 2016) and the reader is referred to that document for a more thorough discussion of alternative strategies. The plan's authors recognized the challenges of selecting a marking and tagging strategy that meets all objectives of management and monitoring while, at the same time, is both practical and avoids negative effects to marked fish. Each marking and tagging strategy considered in that document conferred at least one tangible disadvantage in regards to cost, feasibility, the ability to achieve all of the management and monitoring objectives, or the potential to impose a survival disadvantage to marked fish. Since no identified strategy for marking and tagging was unequivocally superior to others, the authors of the Reintroduction Plan deferred recommendation of a marking and tagging strategy until a later time.

Based on the assessment of marking and tagging contained in the Reintroduction Plan (McConnaha et al. 2016), and with consideration given to the aforementioned monitoring and management needs, the Fish Management Agencies selected a marking and tagging strategy for Jumpstart SRWCS consisting of an adipose fin clip, coded-wire tag, and removal of the left pelvic fin (i.e., ventral fin). The rational for this decision is that this marking and tagging strategy is feasible and will allow captive broodstock progeny to be reliably identified in all existing management and monitoring programs throughout their life cycle and geographic range. A principal benefit of this marking and tagging strategy compared to others being considered was the ability to identify captive broodstock progeny in existing ocean fishery monitoring programs. Primary uncertainties of this marking and tagging strategy are associated with the permanence of the pelvic fin clip as a life-long mark (e.g., permanence depends on application proficiency) and the possibility that removal of a pelvic fin negatively may affect post-release survival. Previous evaluations of fin clip effects on salmonid survival have produced mixed results, ranging from no detectable effects (Bumgarner et al. 2009 and Jones et al. 1997, as cited in McConnaha et al. 2016) to reductions in excess of 50% (Eriksen et al. 2011 and Mears and Hatch 1976, as cited in McConnaha et al. 2016). A large reduction in survivability resulting from the marking and tagging process could compromise the success of Jumpstart reintroduction efforts and fail to take advantage of the full potential value of captive broodstock. It has been recommended that studies be developed to determine negative

consequences of using a pelvic clip as the additional identifiable mark, and USFWS may pursue these studies in the future.

Fish Health

Management Action:

Weekly fish health monitoring of captive broodstock progeny during tagging operations was conducted to assess stress and other potential impacts of double tagging (CWT and left pelvic fin clip) operations. Pre-liberation health examinations of captive broodstock progeny were initiated on February 5 and completed on February 23, 2018. Fish health screening included virology, culturable bacteria, and *Renibacterium salmoninarum*; and no pathogens were detected (Attachment 1). One raceway of juvenile SRWCS contracted a low-level infection of cold-water disease *Flavobacterium psychrophilum* after examination but prior to their release into Battle Creek.

Rationale:

Monitoring and evaluations of fish health must be completed prior to releasing fish from a federal fish hatchery. Fish health examinations of Jumpstart SRWCS were conducted by the USFWS California-Nevada Fish Health Center.

In early March 2018, after completion of pre-liberation health examinations, but prior to releasing all of the Jumpstart SRWCS into Battle Creek, one raceway (Raceway 42; CWT 056176) of SRWCS juveniles were diagnosed with a low level infection of cold-water disease Flavobacterium psychrophilium. Level of infection, and increasing water temperatures prevented further progression of Flavobacterium psychrophilium infections, and treatment was not warranted for this group of fish. The raceway was released upon recommendation of the California-Nevada Fish Health Center.

Fine-scale Imprinting

Management Action:

No action taken

Rationale:

To promote imprinting to specific reaches of Battle Creek where SRWCS are desired to return to spawn, a multi-stakeholder team investigated opportunities to develop an acclimation-imprinting facility on North Fork Battle Creek. North Fork Battle Creek is considered to be more suitable than South Fork Battle Creek or the mainstem of Battle Creek because of cooler temperatures and higher base flows, resulting in improved SRWCS spawning habitats. More specifically, the Feeder Reach, which extends from North Battle Creek Feeder Diversion Dam (river mile [RM] 9.42) downstream to Eagle Canyon Diversion Dam (RM 5.23), is regarded as optimal for SRWCS (Figure 3; Ward and Keir 1999). By rearing juvenile SRWCS in water from North Fork Battle Creek for a period of time prior to release, it may be possible to improve their homing to the specific stream sections where SRWCS spawning is likely to be most successful. Coleman NFH is located on the mainstem Battle Creek (RM 5.97), approximately 16 miles downstream from their optimal habitat and 11 miles downstream from the confluence of North Fork Battle Creek and South Fork Battle Creek (RM 16.80), precluding imprinting on only North Fork Battle

Creek water. Efforts to develop an acclimation/imprinting facility in the watershed of North Fork Battle Creek, however, were hindered by several factors, including;

1) *Limited stream access points to North Fork Battle Creek due to the steep terrain. Especially limited are access points with sufficient space and access to water for an acclimation facility;*
2) *Properties of the Pacific Gas and Electric Company (PG&E) currently have access restrictions associated with construction, modifications, and testing of hydropower facilities associated with the BCRP, and;*
3) *Limited time and funding were available to identify and develop a suitable acclimation/imprinting facility.*

As a result of these impediments, an acclimation/imprinting facility was not developed on North Fork Battle Creek for Jumpstart SRWCS spawned in 2017. Development of an acclimation-imprinting facility may be reconsidered for releases from the Jumpstart project in future years. Because winter Chinook Salmon could not be reared for an extended period in North Fork Battle Creek, we believe that there is an increased likelihood that captive broodstock progeny may not imprint to the most suitable spawning areas; this increases the uncertainty about where adults from this brood year will return to spawn in future years.

Juvenile Releases

Management Action:

Progeny of winter Chinook captive broodstock were released into the North Fork Battle Creek at Wildcat Road Bridge (Figure 3) on four dates between March 2 and April 6, 2018 (Table 4). Number of fish in each release group ranged from approximately 25,000 (April 6, 2018) to more than 92,000 (March 14, 2018). Average fork length of fish at liberation ranged from 71 – 80mm; to take advantage of favorable environmental conditions, several groups of fish were released at a size marginally smaller than winter Chinook typically released from the Sacramento River Supplementation Program. Three of four releases coincided with precipitation events in the northern Central Valley, which resulted in increased flows and turbidity in Battle Creek and the Sacramento River (Figure 2). Battle Creek flow exceeded 7,800 cfs coincident with the final release into Battle Creek, subjecting fish to potential diversion at a compromised levee in lower Battle Creek.

Rationale:

Strategy for releasing juvenile SRWCS into Battle Creek can have a large influence on post-release survival, and thereby affect the success of the jumpstart project. Release strategy for the jumpstart project focused on achieving high levels of abundance and diversity as the two primary objectives. Release strategies that encourage high survival will promote larger numbers of SRWCS adults returning to Battle Creek, retaining more of the genetic and phenotypic diversity of their parents. Genetic diversity provides the basis for adaptation to novel habitats. Abundance and diversity are the same priorities used in developing the overall Reintroduction Plan (McConnaha et al. 2016). Considerations associated with the release of SRWCS captive broodstock progeny into Battle Creek to promote high levels of abundance and diversity are discussed below.

Release Location-

Location where hatchery salmon are released can affect survival and homing. Juvenile salmon are "imprinted" to the distinctive odors of their natal tributary, which enables

them to "remember" olfactory cues and relocate the particular stream (i.e., homing) when they return as adults to spawn (Hasler and Scholz 1983). This adaptation reduces reproductive loss by ensuring that spawning will occur in suitable spawning areas. Timing of imprinting in salmon is highly linked to elevated thyroxine levels associated with the parr-smolt transformation process. This explains why salmon that are raised at a hatchery but released as smolts at another location tend to return as adults to the release site, not the rearing site. However, populations of salmon that emigrate soon after emergence are also able to imprint properly as alevins and emergent fry, demonstrating that the imprinting process is flexible both spatially and temporally (Dittman and Quinn 1996).

To promote homing to the locations of Battle Creek where SRWCS will have the best chances for successful reproduction, we attempted to release captive broodstock progeny at or near the smolt stage and at the area they are desired to return to spawn. The Feeder Reach has been identified as the area where SRWCS are likely to have the best likelihood of successful reproduction (Ward and Kier 1999), therefore, release in this stream reach is preferred. However, the number of potential release sites in North Fork Battle Creek is constrained by rough terrain and limited access points. A multi-stakeholder team identified and considered the following possible release locations on North Fork Battle Creek, listed in order of preference based on proximity to favorable spawning habitats: (1) North Battle Creek Feeder Diversion Dam, (2) Wilson Hill Road Bridge, and (3) Wildcat Road Bridge (Figure 3). If none of these options were feasible, releasing the progeny of SRWCS captive broodstock into Battle Creek at CNFH was a fourth, albeit less desirable, option.

Releasing progeny of SRWCS captive broodstock near to PG&E's North Battle Creek Feeder Diversion Dam and Eagle Canyon Diversion Dam hydropower facilities could subject juvenile fish to impacts associated with construction and start-up testing of the new hydropower and fish facilities. Planned testing of facility automation programming and operations, which are necessary for facility start-up and transfer, were scheduled to occur between March and September 2018, potentially overlapping with the release of SRWCS into Battle Creek. Juvenile SRWCS released in the proximity of these activities could be subject to diversion or dewatering. Exact timing of these tests was unknown and dependent on a variety of factors, including stream flow in Battle Creek. Due the uncertainties associated with the timing of facilities testing, the decision was made to abandon consideration of the two upper-most release locations - North Battle Creek Feeder Diversion Dam and Wilson Hill Road Bridge - to avoid the potential for impacts to juvenile salmon. The selected release site, located at the Wildcat Road Bridge, is the next-most upstream release location considered by the multi-stakeholder team. The Wildcat Road Bridge is on North Fork Battle Creek (0.9 mile from confluence with South Fork Battle Creek), downstream of the preferred spawning area. By releasing juvenile SRWCS at the Wildcat Road Bridge, impacts associated with facilities testing were avoided while, at the same time, promoting imprint to the North Fork Battle Creek, near to the preferred spawning location.

Release Timing-

Several factors associated with the timing of salmon releases from a hatchery are known to influence their survival. Juvenile salmon from the SRWCS Supplementation Program are typically released in February, when fish approach smolt stage and when winter storm events are expected to create favorable environmental conditions in the emigration corridor. However, spawning of captive broodstock occurred later than that of naturally-reared SRWCS, and progeny of captive broodstock were not sufficiently developed for a February release. Later in the spring, environmental conditions are likely to be a constraining factor, as water temperature in lower Sacramento River and Delta typically increase during April, potentially resulting in thermal stress and increased predation. Based on these constraints, we targeted a March release for progeny of SRWCS captive broodstock. Timing the release of SRWCS captive broodstock progeny in March appeared to reasonably balance the goals of releasing juveniles at or near the smolt stage, at a time when spring storm events are expected to create favorable conditions for emigration, and prior to the deterioration of water conditions in the lower Sacramento River and Delta.

Because of inherent uncertainties associated with forecasting juvenile growth and environmental conditions, identifying specific release dates for SRWCS captive broodstock progeny was an adaptive process, based on 'real-time' information associated with several factors, including: (1) fish size and life stage, (2) weather and environmental conditions, (3) managed flow releases (i.e., discharge) from Shasta Dam, (4) number of fish in a release group, and (5) flooding at a compromised levee in lower Battle Creek. Each of these factors is thought to be influential to survival of juvenile SRWCS released into Battle Creek. Likely effects of these factors on survival of juvenile SRWCS are briefly discussed below.

1. *Size and Life Stage*

   Size and life stage at the time of release from a hatchery are known to influence the survival of juvenile salmon. Generally, salmon that are larger and older at the time of their release survive to maturity more than fish that are younger and smaller. Substantial data support releasing juvenile salmon at or near the smolt stage to produce increased returns of adult salmon, as compared to releases at earlier life stages (Kevin Niemela, USFWS, Red Bluff CA, unpublished data). To promote increased returns of adult SRWCS to Battle Creek, juveniles produced in the Supplementation Program are released at or near pre-smolt/smolt life stage. Releasing fish at the pre-smolt/smolt life stage attempts to strike a balance between achieving a reasonably high rate of survival while, at the same time, subjecting hatchery fish to some of the natural selective forces during their early life history. Releases at pre-smolt/smolt life stage are also recommended in the Reintroduction Program.

2. *Weather and Environmental Conditions*

   Environmental conditions at the time of release from a hatchery are a primary influence on their survival. Ideally, releases of SRWCS would be timed to occur in association with winter/spring storm events in the northern Central Valley.

Storm events associated with substantial precipitation result in increased flows and high turbidity in Battle Creek and the Sacramento River; these conditions are generally associated with increased rates of emigration and decreased predation on juvenile salmon. Alternatively, low flows and clear water are generally associated with slower rates of emigration and increased predation; conditions that lead to decreased survival.

3. *Managed Flow Releases from Shasta Dam*

   Emigrating juvenile salmonids are thought to be aided in their downstream migration by increased flows (Raymond 1968; Connor et al. 2011). The downstream migration of salmon smolts may be initiated by increased water flow (see review in Jonsson 1991). Additionally, increased river flows may reduce likelihood of predation and diversion, as emigrating juveniles are able to disperse across a broader area of the river corridor. Timing releases of hatchery SRWCS to coincide with a period of increased discharge from Shasta Dam, including the possibility of a managed pulse flow, may contribute to increased survival during emigration of hatchery releases. However, we hypothesize that it is unlikely that increased discharge from Shasta Dam would have a similar benefit to the survival of juvenile hatchery salmon compared to equivalent flow increases resulting from natural precipitation events; this difference is due to limitations of the magnitude, duration and lack of turbidity associated with managed flow events. Therefore, we considered synchronizing juvenile releases to coincide with natural flow events to be a higher priority.

4. *Number of Fish in a Release Group*

   Anecdotal and experimental evidence and ecological theory suggest that releasing very large numbers of juvenile salmon at a single place and time may improve their survival through the emigration corridor by overwhelming or satiating predators, thereby conferring increased protection for the masses (Furey 2016, Pitcher 1986). Benefit of en masse releases is expected to be greatest when the number of fish released is large and size (i.e., length and area) of the emigration corridor small. However, ability to achieve significant benefits to survival by conducting an en masse release of winter Chinook into Battle Creek is highly uncertain. An association between number of fish in a release group and survival was not evident in a previous acoustic tagging study of late-fall Chinook from the CNFH (R. Null, Pers. Comm. USFWS, Anderson, CA). Furthermore, because total number (~215,000) of SRWCS to be released into Battle Creek is relatively small and length and area of the emigration corridor are large, we anticipate that potential benefits to survival would be attenuated as fish move throughout the emigration corridor.

   We believe that any benefits resulting from an en masse release would likely be localized near the release location in Battle Creek and unlikely to persist downstream as fish distribute across time and space. However, it is also possible that release of SRWCS into Battle Creek could be timed to coincide with a release of fall Chinook Salmon from the CNFH. In this situation, the number of juveniles

released simultaneously could be substantially increased, potentially affording an increased level of protection through the river corridor. Since winter Chinook captive broodstock progeny were larger than juvenile fall Chinook Salmon from the CNFH, they would have a competitive advantage during concurrent emigration. The final release of approximately 25,000 SRWCS captive broodstock progeny on April 6, 2018 coincided with the release of nearly 4 million fall Chinook Salmon smolts into Battle Creek.

An alternative approach to an en masse release strategy is one that temporally separates the total number of fish to be released across multiple distinct releases. This approach does not intend to capitalize on potential benefits afforded by strength in numbers, but rather, intends to control and reduce risks of incurring substantial losses to the entire hatchery production by spreading total number of fish across multiple discrete releases. This release strategy provides an added level of insurance that the entire hatchery production would not suffer severe consequences in the event of, for example, a catastrophic vehicle accident during transport or an isolated and substantial predation event following release.

5. *Flooding at a Compromised Levee on Lower Battle Creek*
   Erosion of a levee on lower Battle Creek (RM 3.09), along a section of property known as Rancho Breisgau, has created a situation where high flows overtop the levee and inundate an area of wooded lowland. Fishes that become entrained into the flooded woodland are susceptible to predation and stranding. Overtopping of the levee has been shown to occur at flows >1,800 cfs; however, the extent that fishes become entrained at these high flows is not known. Concerns of entrainment at the Rancho Breisgau levee breach during high flow events must be balanced against benefits to survival provided by releasing fish during high flow events. Storm events that bring about high flows and turbidity are generally thought to confer a survival advantage to emigrating salmon (see Weather and Environmental Conditions, above).

Next Steps

The Fish Management Agencies have determined that the Battle Creek Jumpstart Project should be continued until the Reintroduction Program is implemented. Releases of brood year 2017 SRWCS captive broodstock progeny into Battle Creek have been completed and preparations are being made to continue the Jumpstart efforts for brood year 2018 and beyond, if necessary. Information generated from monitoring and assessments of juvenile emigrations, harvest monitoring, and spawning escapement of brood year 2017 captive broodstock progeny will be used, as available, to evaluate the initial jumpstart efforts. Future actions will build upon the lessons learned from the 2017 - 2018 production cycle, modifying as necessary, to improve project performance. USFWS will develop a "Transition Plan" to outline a strategy for continuing the Jumpstart Project and describe the process of merging the Jumpstart Project with the Reintroduction Plan.

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TABLE 1.—Record of broodstock pairings and egg production for Sacramento River Winter Chinook captive broodstock spawned at the Livingston Stone National Fish Hatchery in 2017.

	Female			Male			Green eggs			
Spawn Date	ID number	Length (mm)	Origin	ID number	Origin	Family Group ID	Per cross	Per female	Eyed Eggs	Percent Eyed Eggs
7/25/2017	17-85776	n/a	Captive	17-85124	Captive	L1(14)A	1,066	1,066	1,046	98.12%
7/25/2017	17-85490	n/a	Captive	17-85240	Captive	L2(14)B	1,955	1,955	1,892	96.78%
7/31/2017	17-85278	440	Captive	17-80124	Natural	L3CN	482	1,015	464	96.27%
7/31/2017	17-85278	440	Captive	17-80231	Natural	L3CP	533	1,015	516	96.81%
7/31/2017	17-85775	450	Captive	17-80229	Natural	L4CO	350	721	236	67.43%
7/31/2017	17-85775	450	Captive	17-80231	Natural	L4CP	371	721	259	69.81%
7/31/2017	17-85961	480	Captive	17-80124	Natural	L5CN	916	1,801	912	99.56%
7/31/2017	17-85961	480	Captive	17-80229	Natural	L5CO	885	1,801	871	98.42%
7/31/2017	17-85169	430	Captive	17-85124	Captive	L6(14)A	628	1,159	546	86.94%
7/31/2017	17-85169	430	Captive	17-80124	Natural	L6CN	531	1,159	462	87.01%
7/31/2017	17-85744	390	Captive	17-87324	Captive	L7(15)D	417	839	268	64.27%
7/31/2017	17-85744	390	Captive	17-86853	Captive	L7(15)E	422	839	264	62.56%
8/2/2017	17-85978	480	Captive	17-86912	Captive	L8(15)F	919	1,737	252	27.42%
8/2/2017	17-85978	480	Captive	17-86858	Captive	L8(15)G	818	1,737	243	29.71%
8/2/2017	17-85332	420	Captive	17-87568	Captive	L9(15)H	456	1,019	46	10.09%
8/2/2017	17-85332	420	Captive	17-87209	Captive	L9(15)I	563	1,019	108	19.18%
8/2/2017	17-85342	355	Captive	17-80439	Natural	L10CT	460	460	84	18.26%
8/2/2017	17-85547	420	Captive	17-80447	Natural	L11CU	711	711	129	18.14%
8/3/2017	17-85730	480	Captive	17-85989	Captive	L12(14)J	671	1,337	218	32.49%
8/3/2017	17-85730	480	Captive	17-85148	Captive	L12(14)K	666	1,337	623	93.54%
8/3/2017	17-85119	500	Captive	17-85428	Captive	L13(14)L	n/a	Soft Shell	n/a	n/a
8/3/2017	17-85119	500	Captive	17-86636	Captive	L13(15)M	n/a	Soft Shell	n/a	n/a
8/3/2017	17-85648	400	Captive	17-85989	Captive	L14(14)J	368	780	135	36.68%
8/3/2017	17-85648	400	Captive	17-85124	Captive	L14(14)A	412	780	340	82.52%
8/3/2017	17-85092	400	Captive	17-85124	Captive	L15(14)A	184	442	34	18.48%
8/3/2017	17-85092	400	Captive	17-85060	Captive	L15(14)O	258	442	64	24.81%
8/3/2017	17-86004	390	Captive	17-85148	Captive	L16(14)K	341	722	279	81.82%
8/3/2017	17-86004	390	Captive	17-85428	Captive	L16(14)L	381	722	315	82.68%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/7/2017	17-85461	440	Captive	17-85148	Captive	L17(14)K	698	698	1	0.14%
8/7/2017	17-85461	440	Captive	17-80232	Natural	L17CS	n/a	Soft Shell	n/a	n/a
8/7/2017	17-85506	520	Captive	17-85060	Captive	L18(14)O	935	1,908	888	94.97%
8/7/2017	17-85506	520	Captive	17-80356	Natural	L18CW	973	1,908	935	96.09%
8/7/2017	17-85294	450	Captive	17-80408	Natural	L19CX	672	1,283	644	95.83%
8/7/2017	17-85294	450	Captive	17-80232	Natural	L19CS	611	1,283	592	96.89%
8/7/2017	17-85072	480	Captive	17-86863	Captive	L20(15)P	785	1,476	752	95.80%
8/7/2017	17-85072	480	Captive	17-80408	Natural	L20CX	691	1,476	680	98.41%
8/7/2017	17-86024	450	Captive	17-87324	Captive	L21(15)D	718	1,248	713	99.30%
8/7/2017	17-86024	450	Captive	17-80356	Natural	L21CW	530	1,248	522	98.49%
8/8/2017	17-85467	504	Captive	17-86863	Captive	L22(15)P	1,148	2,175	1,047	91.20%
8/8/2017	17-85467	504	Captive	17-85678	Captive	L22(14)AQ	1,027	2,175	922	89.78%
8/8/2017	17-85269	470	Captive	17-85580	Captive	L23(14)R	887	1,583	884	99.66%
8/8/2017	17-85269	470	Captive	17-87329	Captive	L23(15)S	696	1,583	684	98.28%
8/8/2017	17-85606	495	Captive	17-87303	Captive	L24(15)T	703	1,449	669	95.16%
8/8/2017	17-85606	495	Captive	17-85580	Captive	L24(14)R	746	1,449	713	95.58%
8/9/2017	17-85959	505	Captive	17-87031	Captive	L25(15)U	802	1,756	786	98.00%
8/9/2017	17-85959	505	Captive	17-87325	Captive	L25(15)V	954	1,756	938	98.32%
8/9/2017	17-85946	500	Captive	17-86637	Captive	L26(15)W	773	1,588	737	95.34%
8/9/2017	17-85946	500	Captive	17-80425	Natural	L26CQ	815	1,588	794	97.42%
8/9/2017	17-85155	470	Captive	17-86943	Captive	L27(15)AS	733	1,488	725	98.91%
8/9/2017	17-85155	470	Captive	17-87303	Captive	L27(15)T	755	1,488	734	97.22%
8/9/2017	17-85009	440	Captive	17-80422	Natural	L28CV	656	1,213	621	94.66%
8/9/2017	17-85009	440	Captive	17-80425	Natural	L28CQ	557	1,213	517	92.82%
8/9/2017	17-85521	480	Captive	17-86637	Captive	L29(15)W	859	1,694	764	88.94%
8/9/2017	17-85521	480	Captive	17-85866	Captive	L29(14)AX	835	1,694	777	93.05%
8/9/2017	17-86025	495	Captive	17-86022	Captive	L30(14)Z	841	1,678	751	89.30%
8/9/2017	17-86025	495	Captive	17-87339	Captive	L30(15)AA	837	1,678	746	89.13%
8/9/2017	17-85371	490	Captive	17-86769	Captive	L31(15)AB	887	1,902	823	92.78%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/9/2017	17-85371	490	Captive	17-87524	Captive	L31(15)AC	1,015	1,902	949	93.50%
8/9/2017	17-85245	479	Captive	17-80422	Natural	L32CV	629	1,336	589	93.64%
8/9/2017	17-85245	479	Captive	17-86022	Captive	L32(14)Z	707	1,336	668	94.48%
8/9/2017	17-85921	460	Captive	17-86595	Captive	L33(15)AD	776	1,427	769	99.10%
8/9/2017	17-85921	460	Captive	17-86769	Captive	L33(15)AB	651	1,427	647	99.39%
8/15/2017	17-85251	570	Captive	17-5516	Captive	L34(14)AE	1,451	3,008	1,401	96.55%
8/15/2017	17-85251	570	Captive	17-85298	Captive	L34(14)AF	1,557	3,008	1,522	97.75%
8/15/2017	6752945	480	Captive	17-87329	Captive	L35(15)S	760	1,474	748	98.42%
8/15/2017	6752945	480	Captive	17-87031	Captive	L35(15)U	714	1,474	706	98.88%
8/15/2017	17-85527	460	Captive	17-85659	Captive	L36(14)AG	502	1,042	482	96.02%
8/15/2017	17-85527	460	Captive	17-85516	Captive	L36(14)AH	540	1,042	526	97.41%
8/15/2017	17-85450	450	Captive	17-85328	Captive	L37(14)AI	633	1,221	528	83.41%
8/15/2017	17-85450	450	Captive	17-87325	Captive	L37(15)V	588	1,221	481	81.80%
8/15/2017	17-85507	455	Captive	17-87456	Captive	L38(15)AJ	655	1,294	642	98.02%
8/15/2017	17-85507	455	Captive	17-85375	Captive	L38(14)AE	639	1,294	628	98.28%
8/15/2017	17-85760	430	Captive	17-86777	Captive	L39(15)AL	571	1,272	532	93.17%
8/15/2017	17-85760	430	Captive	17-87209	Captive	L39(15)I	701	1,272	652	93.01%
8/15/2017	17-85481	390	Captive	17-86595	Captive	L40(15)AD	507	507	448	88.36%
8/15/2017	17-85828	410	Captive	17-87339	Captive	L41(15)AA	186	186	2	1.08%
8/15/2017	17-85564	480	Captive	17-86620	Captive	L42(15)AM	724	1,478	658	90.88%
8/15/2017	17-85564	480	Captive	17-87391	Captive	L42(15)AN	754	1,478	710	94.16%
8/15/2017	17-86177	430	Captive	17-87391	Captive	L43(15)AN	740	1,596	685	92.57%
8/15/2017	17-86177	430	Captive	17-87456	Captive	L43(15)AJ	856	1,596	813	94.98%
8/15/2017	17-85028	460	Captive	17-87345	Captive	L44(15)AO	768	1,587	760	98.96%
8/15/2017	17-85028	460	Captive	17-85981	Captive	L44(14)AP	819	1,587	803	98.05%
8/15/2017	17-85607	450	Captive	17-85981	Captive	L45(14)AP	645	1,267	620	96.12%
8/15/2017	17-85607	450	Captive	17-87345	Captive	L45(15)AO	622	1,267	599	96.30%
8/15/2017	17-85792	490	Captive	17-85516	Captive	L46(14)AH	765	1,464	760	99.35%
8/15/2017	17-85792	490	Captive	17-85678	Captive	L46(14)AQ	699	1,464	695	99.43%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/15/2017	17-86047	405	Captive	17-87047	Captive	L47(15)AR	531	1,008	526	99.06%
8/15/2017	17-86047	405	Captive	17-86943	Captive	L47(15)AS	477	1,008	473	99.16%
8/15/2017	17-85909	470	Captive	17-85659	Captive	L48(14)AG	769	1,530	746	97.01%
8/15/2017	17-85909	470	Captive	17-85140	Captive	L48(14)AT	761	1,530	723	95.01%
8/15/2017	17-85658	350	Captive	17-86828	Captive	L49(15)AU	761	1,309	554	72.80%
8/15/2017	17-85658	350	Captive	17-85842	Captive	L49(14)AV	548	1,309	539	98.36%
8/15/2017	17-85363	415	Captive	17-85842	Captive	L50(14)AV	411	869	353	85.89%
8/15/2017	17-85363	415	Captive	17-86943	Captive	L50(15)AS	458	869	400	87.34%
8/16/2017	17-85650	430	Captive	17-85493	Captive	L51(14)AW	513	1,133	47	9.16%
8/16/2017	17-85650	430	Captive	17-85140	Captive	L51(14)AT	620	1,133	67	10.81%
8/16/2017	17-85349	400	Captive	17-86620	Captive	L52(15)AM	473	897	454	95.98%
8/16/2017	17-85349	400	Captive	17-85866	Captive	L52(14)AX	424	897	413	97.41%
8/16/2017	17-85984	480	Captive	17-85771	Captive	L53(14)AY	678	1,339	648	95.58%
8/16/2017	17-85984	480	Captive	17-85729	Captive	L53(14)AZ	661	1,339	622	94.10%
8/16/2017	17-85667	480	Captive	17-86777	Captive	L54(15)AL	748	1,491	654	87.43%
8/16/2017	17-85667	480	Captive	17-85045	Captive	L54(14)BA	743	1,491	669	90.04%
8/16/2017	17-85562	440	Captive	17-87191	Captive	L55(15)BB	580	1,084	282	48.62%
8/16/2017	17-85562	440	Captive	17-85729	Captive	L55(14)AZ	504	1,084	243	48.21%
8/16/2017	17-85976	490	Captive	17-87191	Captive	L56(15)BB	823	1,527	784	95.26%
8/16/2017	17-85976	490	Captive	17-85429	Captive	L56(14)BC	704	1,527	640	90.91%
8/16/2017	17-86001	460	Captive	17-85771	Captive	L57(14)AY	652	1,212	617	94.63%
8/16/2017	17-86001	460	Captive	17-85375	Captive	L57(14)AE	560	1,212	472	84.29%
8/16/2017	17-85541	510	Captive	17-85375	Captive	L58(14)AE	n/a	Soft Shell	n/a	n/a
8/16/2017	17-85541	510	Captive	17-85493	Captive	L58(14)AW	n/a	Soft Shell	n/a	n/a
8/17/2017	17-85975	450	Captive	17-87434	Captive	L59(15)BD	583	1,111	375	64.32%
8/17/2017	17-85975	450	Captive	17-85328	Captive	L59(14)BE	528	1,111	352	66.67%
8/17/2017	17-85970	435	Captive	17-87047	Captive	L60(15)AR	442	933	390	88.24%
8/17/2017	17-85970	435	Captive	17-86828	Captive	L60(15)AU	491	933	461	93.89%
8/17/2017	17-85691	395	Captive	17-85516	Captive	L61(14)AH	339	675	317	93.51%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/17/2017	17-85691	395	Captive	17-86809	Captive	L61(15)BG	336	675	316	94.05%
8/17/2017	17-85843	435	Captive	17-87434	Captive	L62(15)BD	746	1,495	513	68.77%
8/17/2017	17-85843	435	Captive	17-86809	Captive	L62(15)BG	749	1,495	529	70.63%
8/17/2017	17-86029	435	Captive	17-85516	Captive	L63(14)AH	529	1,189	506	95.65%
8/17/2017	17-86029	435	Captive	17-85429	Captive	L63(14)BC	660	1,189	632	95.76%
8/17/2017	17-85447	440	Captive	17-87421	Captive	L64(15)BH	700	1,321	571	81.57%
8/17/2017	17-85447	440	Captive	17-85545	Captive	L64(14)BI	621	1,321	573	92.27%
8/17/2017	17-85066	380	Captive	17-87421	Captive	L65(15)BH	366	759	332	90.71%
8/17/2017	17-85066	380	Captive	17-87524	Captive	L65(15)AC	393	759	321	81.68%
8/17/2017	17-85280	390	Captive	17-86605	Captive	L66(15)BJ	462	838	370	80.09%
8/17/2017	17-85280	390	Captive	17-87568	Captive	L66(15)H	376	838	310	82.45%
8/17/2017	17-86023	440	Captive	17-86605	Captive	L67(15)BJ	670	1,294	647	96.57%
8/17/2017	17-86023	440	Captive	17-86777	Captive	L67(15)AL	624	1,294	591	94.71%
8/17/2017	17-85320	450	Captive	17-85045	Captive	L68(14)BA	689	1,384	628	91.15%
8/17/2017	17-85320	450	Captive	17-86769	Captive	L68(15)AB	695	1,384	639	91.94%
8/17/2017	17-85308	410	Captive	17-86605	Captive	L69(15)BJ	508	1,097	493	97.05%
8/17/2017	17-85308	410	Captive	17-86943	Captive	L69(15)AS	589	1,097	565	95.93%
8/23/2017	17-85244	410	Captive	17-87249	Captive	L70(15)BK	411	822	392	95.26%
8/23/2017	17-85244	410	Captive	17-85661	Captive	L70(14)BL	411	822	392	95.26%
8/23/2017	17-85673	420	Captive	17-87249	Captive	L71(15)BK	433	866	406	93.76%
8/23/2017	17-85673	420	Captive	17-85661	Captive	L71(14)BL	433	866	406	93.76%
8/23/2017	17-85446	400	Captive	17-87490	Captive	L72(15)BM	487	973	472	96.92%
8/23/2017	17-85446	400	Captive	17-86792	Captive	L72(15)BN	487	973	472	96.92%
8/23/2017	17-85573	410	Captive	17-87490	Captive	L73(15)BM	411	822	392	95.26%
8/23/2017	17-85573	410	Captive	17-86792	Captive	L73(15)BN	411	822	392	95.26%
8/23/2017	17-85214	480	Captive	17-86755	Captive	L74(15)BO	770	1,540	743	96.43%
8/23/2017	17-85214	480	Captive	17-86839	Captive	L74(15)BP	770	1,540	743	96.43%
8/23/2017	17-85176	470	Captive	17-86755	Captive	L75(15)BO	729	1,458	367	50.34%
8/23/2017	17-85176	470	Captive	17-86839	Captive	L75(15)BP	729	1,458	367	50.34%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/23/2017	17-85492	490	Captive	17-85679	Captive	L76(14)BQ	641	1,282	639	99.69%
8/23/2017	17-85492	490	Captive	17-85285	Captive	L76(14)BR	641	1,282	639	99.69%
8/23/2017	17-85987	450	Captive	17-85682	Captive	L77(14)BS	751	1,502	697	92.81%
8/23/2017	17-85987	450	Captive	17-85679	Captive	L77(14)BQ	751	1,502	697	92.81%
8/23/2017	17-85666	460	Captive	17-85285	Captive	L78(14)BR	657	1,314	645	98.10%
8/23/2017	17-85666	460	Captive	17-85682	Captive	L78(14)BS	657	1,314	645	98.10%
8/23/2017	17-85752	470	Captive	17-85569	Captive	L79(14)BT	809	1,618	297	36.65%
8/23/2017	17-85752	470	Captive	17-87112	Captive	L79(15)BU	809	1,618	297	36.65%
8/23/2017	17-85584	510	Captive	17-85569	Captive	L80(14)BT	873	1,745	857	98.22%
8/23/2017	17-85584	510	Captive	17-87112	Captive	L80(15)BU	873	1,745	857	98.22%
8/23/2017	17-85123	430	Captive	17-85209	Captive	L81(14)BV	511	1,021	490	95.89%
8/23/2017	17-85123	430	Captive	17-85372	Captive	L81(14)BW	511	1,021	490	95.89%
8/23/2017	17-85207	470	Captive	17-85209	Captive	L82(14)BV	659	1,317	613	93.01%
8/23/2017	17-85207	470	Captive	17-85372	Captive	L82(15)BW	659	1,317	613	93.01%
8/23/2017	17-85425	510	Captive	17-87418	Captive	L83(15)BX	718	1,436	683	95.06%
8/23/2017	17-85425	510	Captive	17-86827	Captive	L83(15)BY	718	1,436	683	95.06%
8/23/2017	17-85662	560	Captive	17-87418	Captive	L84(15)BX	1,145	2,290	1,104	96.38%
8/23/2017	17-85662	560	Captive	17-86827	Captive	L84(15)BY	1,145	2,290	1,104	96.38%
8/23/2017	17-86181	455	Captive	17-87030	Captive	L85(15)BZ	728	1,455	527	72.44%
8/23/2017	17-86181	455	Captive	17-86589	Captive	L85(15)CA	728	1,455	527	72.44%
8/23/2017	17-85172	480	Captive	17-85545	Captive	L86(14)BI	784	1,567	766	97.77%
8/23/2017	17-85172	480	Captive	17-87030	Captive	L86(15)BZ	784	1,567	766	97.77%
8/23/2017	17-85402	490	Captive	17-86589	Captive	L87(15)CA	780	1,560	752	96.35%
8/23/2017	17-85402	490	Captive	17-86799	Captive	L87(15)CB	780	1,560	752	96.35%
8/23/2017	17-86160	450	Captive	17-86589	Captive	L88(15)CA	713	1,425	675	94.67%
8/23/2017	17-86160	450	Captive	5682678	Captive	L88(15)CC	713	1,425	675	94.67%
8/23/2017	17-85109	450	Captive	5682678	Captive	L89(15)CC	730	1,460	687	94.04%
8/23/2017	17-85109	450	Captive	17-87431	Captive	L89(15)CD	730	1,460	687	94.04%
8/23/2017	17-85878	470	Captive	17-87431	Captive	L90(15)CD	690	1,379	660	95.72%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/23/2017	17-85878	470	Captive	17-87206	Captive	L90(15)CE	690	1,379	660	95.72%
8/23/2017	17-85077	440	Captive	17-86781	Captive	L91(15)CG	553	1,106	534	96.47%
8/23/2017	17-85077	440	Captive	17-86980	Captive	L91(15)CF	553	1,106	534	96.47%
8/23/2017	17-85478	480	Captive	17-86980	Captive	L92(15)CF	961	1,922	941	97.92%
8/23/2017	17-85478	480	Captive	17-86781	Captive	L92(15)CG	961	1,922	941	97.92%
8/23/2017	17-86184	410	Captive	17-86633	Captive	L93(15)CH	485	970	481	99.18%
8/23/2017	17-86184	410	Captive	17-86771	Captive	L93(15)CI	485	970	481	99.18%
8/23/2017	17-85936	450	Captive	17-86633	Captive	L94(15)CH	486	972	438	90.02%
8/23/2017	17-85936	450	Captive	17-86771	Captive	L94(15)CI	486	972	438	90.02%
8/23/2017	17-85858	420	Captive	17-86701	Captive	L95(15)CJ	601	1,202	564	93.84%
8/23/2017	17-85858	420	Captive	17-86941	Captive	L95(15)CK	601	1,202	564	93.84%
8/23/2017	17-85443	530	Captive	17-86701	Captive	L96(15)CJ	960	1,919	954	99.43%
8/23/2017	17-85443	530	Captive	17-86941	Captive	L96(15)CK	960	1,919	954	99.43%
8/23/2017	17-85793	440	Captive	17-86809	Captive	L97(15)BG	636	1,271	572	90.01%
8/23/2017	17-85793	440	Captive	17-87324	Captive	L97(15)D	636	1,271	572	90.01%
8/23/2017	17-85598	470	Captive	17-87431	Captive	L98(15)CD	607	1,214	588	96.79%
8/23/2017	17-85598	470	Captive	17-86633	Captive	L98(15)CH	607	1,214	588	96.79%
8/23/2017	17-85030	530	Captive	17-86799	Captive	L99(15)CB	1,065	2,130	1,049	98.50%
8/23/2017	17-85030	530	Captive	17-87209	Captive	L99(15)I	1,065	2,130	1,049	98.50%
8/24/2017	17-85296	450	Captive	17-85429	Captive	L100(14)BC	671	1,341	625	93.14%
8/24/2017	17-85296	450	Captive	17-87329	Captive	L100(15)S	671	1,341	625	93.14%
8/24/2017	17-85466	495	Captive	17-85771	Captive	L101(14)AY	876	1,752	772	88.07%
8/24/2017	17-85466	495	Captive	17-87490	Captive	L101(15)BM	876	1,752	772	88.07%
8/24/2017	6752983	440	Captive	17-86769	Captive	L102(15)AB	671	1,341	656	97.76%
8/24/2017	6752983	440	Captive	17-87206	Captive	L102(15)CE	671	1,341	656	97.76%
8/24/2017	17-85628	420	Captive	17-85045	Captive	L103(14)BA	464	928	382	82.22%
8/24/2017	17-85628	420	Captive	17-85285	Captive	L103(14)BR	464	928	382	82.22%
8/24/2017	17-85318	440	Captive	17-85209	Captive	L104(14)BV	591	1,182	516	87.23%
8/24/2017	17-85318	440	Captive	17-85679	Captive	L104(14)BQ	591	1,182	516	87.23%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/24/2017	17-85886	450	Captive	17-87339	Captive	L105(15)AA	480	960	473	98.44%
8/24/2017	17-85886	450	Captive	17-86980	Captive	L105(15)CF	480	960	473	98.44%
8/24/2017	17-85117	430	Captive	17-85678	Captive	L106(14)AQ	613	1,226	101	16.48%
8/24/2017	17-85117	430	Captive	17-86792	Captive	L106(15)BN	613	1,226	101	16.48%
8/24/2017	17-85210	365	Captive	17-85661	Captive	L107(14)BL	336	672	233	69.20%
8/24/2017	17-85210	365	Captive	17-85140	Captive	L107(14)AT	336	672	233	69.20%
8/24/2017	17-85167	430	Captive	17-86589	Captive	L108(15)CA	619	1,237	589	95.15%
8/24/2017	17-85167	430	Captive	17-85981	Captive	L108(14)AP	619	1,237	589	95.15%
8/24/2017	17-85646	480	Captive	17-85569	Captive	L109(14)BT	779	1,557	765	98.20%
8/24/2017	17-85646	480	Captive	17-86941	Captive	L109(15)CK	779	1,557	765	98.20%
8/24/2017	17-86179	410	Captive	17-87206	Captive	L110(15)CE	570	1,139	537	94.21%
8/24/2017	17-86179	410	Captive	17-87191	Captive	L110(15)BB	570	1,139	537	94.21%
8/24/2017	17-85513	470	Captive	17-85375	Captive	L111(14)AE	681	1,362	666	97.72%
8/24/2017	17-85513	470	Captive	17-87391	Captive	L111(15)AN	681	1,362	666	97.72%
8/24/2017	17-86014	520	Captive	17-87325	Captive	L112(15)V	849	1,698	815	95.94%
8/24/2017	17-86014	520	Captive	17-85372	Captive	L112(14)BW	849	1,698	815	95.94%
8/24/2017	17-85585	430	Captive	17-85375	Captive	L113(14)AE	593	1,185	507	85.49%
8/24/2017	17-85585	430	Captive	17-86828	Captive	L113(15)AU	593	1,185	507	85.49%
8/24/2017	17-85393	480	Captive	17-86828	Captive	L114(15)AU	801	1,601	161	20.11%
8/24/2017	17-85393	480	Captive	17-85682	Captive	L114(14)BS	801	1,601	161	20.11%
8/24/2017	17-85237	480	Captive	17-85866	Captive	L115(14)AX	610	1,220	596	97.70%
8/24/2017	17-85237	480	Captive	17-87546	Captive	L115(15)CL	610	1,220	596	97.70%
8/24/2017	17-85968	460	Captive	17-87546	Captive	L116(15)CL	716	1,431	706	98.60%
8/24/2017	17-85968	460	Captive	17-86701	Captive	L116(15)CJ	716	1,431	706	98.60%
8/24/2017	17-85303	430	Captive	17-87546	Captive	L117(15)CL	434	867	412	94.93%
8/24/2017	17-85303	430	Captive	17-86777	Captive	L117(15)AL	434	867	412	94.93%
8/24/2017	17-86045	410	Captive	17-86777	Captive	L118(15)AL	550	1,099	542	98.64%
8/24/2017	17-86045	410	Captive	17-87490	Captive	L118(15)BM	550	1,099	542	98.64%
8/24/2017	17-85374	550	Captive	17-85493	Captive	L119(14)AW	1,008	2,015	998	99.01%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/24/2017	17-85374	550	Captive	17-86777	Captive	L119(15)AL	1,008	2,015	998	99.01%
8/24/2017	17-85149	390	Captive	17-85545	Captive	L120(14)BI	368	735	163	44.22%
8/24/2017	17-85149	390	Captive	17-86771	Captive	L120(15)CI	368	735	163	44.22%
8/24/2017	17-85188	465	Captive	17-87112	Captive	L121(15)BU	577	1,154	573	99.22%
8/24/2017	17-85188	465	Captive	17-86839	Captive	L121(15)BP	577	1,154	573	99.22%
8/24/2017	17-85779	510	Captive	17-87249	Captive	L122(15)BK	1,013	2,025	998	98.57%
8/24/2017	17-85779	510	Captive	17-86827	Captive	L122(15)BY	1,013	2,025	998	98.57%
8/24/2017	17-85951	500	Captive	17-86755	Captive	L123(15)BO	991	1,981	766	77.28%
8/24/2017	17-85951	500	Captive	17-85842	Captive	L123(14)AV	991	1,981	766	77.28%
8/24/2017	17-85407	410	Captive	17-87031	Captive	L124(15)U	453	906	340	74.94%
8/24/2017	17-85407	410	Captive	17-86595	Captive	L124(15)AD	453	906	340	74.94%
8/24/2017	17-85593	420	Captive	17-85659	Captive	L125(14)AG	489	978	473	96.63%
8/24/2017	17-85593	420	Captive	17-85729	Captive	L125(14)AZ	489	978	473	96.63%
8/24/2017	17-85150	440	Captive	17-85580	Captive	L126(14)R	557	1,114	538	96.59%
8/24/2017	17-85150	440	Captive	17-87418	Captive	L126(15)BX	557	1,114	538	96.59%
8/24/2017	17-85762	465	Captive	17-87345	Captive	L127(15)AO	741	1,482	727	98.11%
8/24/2017	17-85762	465	Captive	17-86781	Captive	L127(15)CG	741	1,482	727	98.11%
8/24/2017	17-85047	440	Captive	17-87030	Captive	L128(15)BZ	493	985	461	93.60%
8/24/2017	17-85047	440	Captive	17-87209	Captive	L128(15)I	493	985	461	93.60%
8/24/2017	17-85080	410	Captive	17-85046	Captive	L129(14)CM	497	993	473	95.27%
8/24/2017	17-85080	410	Captive	17-85285	Captive	L129(14)BR	497	993	473	95.27%
8/25/2017	17-85519	460	Captive	17-85981	Captive	L130(14)AP	694	1,387	684	98.56%
8/25/2017	17-85519	460	Captive	17-85866	Captive	L130(14)AX	694	1,387	684	98.56%
8/25/2017	17-85416	490	Captive	17-86839	Captive	L131(15)BP	740	1,480	729	98.51%
8/25/2017	17-85416	490	Captive	17-85209	Captive	L131(14)BV	740	1,480	729	98.51%
8/25/2017	17-85456	435	Captive	17-85545	Captive	L132(14)BI	583	1,166	566	97.08%
8/25/2017	17-85456	435	Captive	17-85372	Captive	L132(14)BW	583	1,166	566	97.08%
8/25/2017	17-85510	410	Captive	17-87031	Captive	L133(15)U	336	672	296	88.10%
8/25/2017	17-85510	410	Captive	17-86777	Captive	L133(15)AL	336	672	296	88.10%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/25/2017	17-85836	475	Captive	17-85429	Captive	L134(14)BC	631	1,262	556	88.03%
8/25/2017	17-85836	475	Captive	17-86701	Captive	L134(15)CJ	631	1,262	556	88.03%
8/25/2017	17-85883	435	Captive	17-86633	Captive	L135(15)CH	528	1,055	522	98.86%
8/25/2017	17-85883	435	Captive	17-86941	Captive	L135(15)CK	528	1,055	522	98.86%
8/25/2017	17-86174	395	Captive	17-87431	Captive	L136(15)CD	488	975	451	92.41%
8/25/2017	17-86174	395	Captive	17-87391	Captive	L136(15)AN	488	975	451	92.41%
8/25/2017	17-85200	370	Captive	17-85729	Captive	L137(14)AZ	303	605	296	97.69%
8/25/2017	17-85200	370	Captive	17-85140	Captive	L137(14)AT	303	605	296	97.69%
8/25/2017	17-85001	465	Captive	17-85679	Captive	L138(14)BQ	662	1,323	527	79.59%
8/25/2017	17-85001	465	Captive	17-86827	Captive	L138(15)BY	662	1,323	527	79.59%
8/25/2017	17-85366	445	Captive	17-87490	Captive	L139(15)BM	293	586	179	61.09%
8/25/2017	17-85366	445	Captive	17-85580	Captive	L139(14)R	293	586	179	61.09%
8/25/2017	17-85015	440	Captive	17-87249	Captive	L140(15)BK	671	1,341	643	95.90%
8/25/2017	17-85015	440	Captive	17-86771	Captive	L140(15)CI	671	1,341	643	95.90%
8/25/2017	17-85977	445	Captive	17-85045	Captive	L141(14)BA	679	1,357	657	96.83%
8/25/2017	17-85977	445	Captive	17-87206	Captive	L141(15)CE	679	1,357	657	96.83%
8/25/2017	17-85623	455	Captive	17-85682	Captive	L142(14)BS	720	1,439	637	88.53%
8/25/2017	17-85623	455	Captive	17-86828	Captive	L142(15)AU	720	1,439	637	88.53%
8/25/2017	17-85454	475	Captive	17-85842	Captive	L143(14)AV	668	1,336	640	95.73%
8/25/2017	17-85454	475	Captive	17-85516	Captive	L143(14)AH	668	1,336	640	95.73%
8/25/2017	17-85178	445	Captive	17-86755	Captive	L144(15)BO	645	1,253	640	99.22%
8/25/2017	17-85178	445	Captive	17-86980	Captive	L144(15)CF	608	1,253	602	99.01%
8/29/2017	17-85505	435	Captive	17-86954	Captive	L145(15)CN	399	798	97	24.31%
8/29/2017	17-85505	435	Captive	17-85788	Captive	L145(14)CO	399	798	97	24.31%
8/29/2017	17-85067	460	Captive	17-86954	Captive	L146(15)CN	689	1,378	682	98.98%
8/29/2017	17-85067	460	Captive	17-85788	Captive	L146(14)CO	689	1,378	682	98.98%
8/29/2017	17-85162	350	Captive	17-86954	Captive	L147(15)CN	967	967	868	89.76%
8/29/2017	17-85112	410	Captive	17-87337	Captive	L148(15)CP	185	369	154	83.47%
8/29/2017	17-85112	410	Captive	17-87094	Captive	L148(15)CQ	185	369	154	83.47%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/29/2017	17-85627	450	Captive	17-87337	Captive	L149(15)CP	705	1,409	671	95.24%
8/29/2017	17-85627	450	Captive	17-87094	Captive	L149(15)CQ	705	1,409	671	95.24%
8/29/2017	17-85449	410	Captive	17-85552	Captive	L150(14)CR	427	853	336	78.66%
8/29/2017	17-85449	410	Captive	17-87094	Captive	L150(15)CQ	427	853	336	78.66%
8/29/2017	17-85029	500	Captive	17-85552	Captive	L151(14)CR	823	1,645	785	95.38%
8/29/2017	17-85029	500	Captive	17-86922	Captive	L151(15)CS	823	1,645	785	95.38%
8/29/2017	17-85181	450	Captive	17-85552	Captive	L152(14)CR	722	1,444	694	96.12%
8/29/2017	17-85181	450	Captive	17-86922	Captive	L152(15)CS	722	1,444	694	96.12%
8/29/2017	17-85565	460	Captive	17-86922	Captive	L153(15)CS	783	1,566	771	98.47%
8/29/2017	17-85565	460	Captive	17-87385	Captive	L153(15)CT	783	1,566	771	98.47%
8/29/2017	17-85530	470	Captive	17-86922	Captive	L154(15)CS	717	1,433	660	92.04%
8/29/2017	17-85530	470	Captive	17-87385	Captive	L154(15)CT	717	1,433	660	92.04%
8/29/2017	17-85235	365	Captive	17-87385	Captive	L155(15)CT	398	796	372	93.34%
8/29/2017	17-85235	365	Captive	17-87407	Captive	L155(15)CU	398	796	372	93.34%
8/29/2017	17-86163	430	Captive	17-87407	Captive	L156(15)CU	400	800	391	97.63%
8/29/2017	17-86163	430	Captive	17-87307	Captive	L156(15)CV	400	800	391	97.63%
8/29/2017	17-85825	430	Captive	17-87407	Captive	L157(15)CU	510	1,019	498	97.64%
8/29/2017	17-85825	430	Captive	17-87307	Captive	L157(15)CV	510	1,019	498	97.64%
8/29/2017	17-85256	400	Captive	17-87307	Captive	L158(15)CV	352	703	349	99.29%
8/29/2017	17-85256	400	Captive	17-87014	Captive	L158(15)CW	352	703	349	99.29%
8/29/2017	17-85803	420	Captive	17-87014	Captive	L159(15)CW	402	803	378	94.15%
8/29/2017	17-85803	420	Captive	17-87138	Captive	L159(15)CX	402	803	378	94.15%
8/29/2017	17-85401	440	Captive	17-87014	Captive	L160(15)CW	570	1,139	544	95.43%
8/29/2017	17-85401	440	Captive	17-87138	Captive	L160(15)CX	570	1,139	544	95.43%
8/29/2017	17-86010	395	Captive	17-87138	Captive	L161(15)CX	279	558	251	89.78%
8/29/2017	17-86010	395	Captive	17-87468	Captive	L161(15)CY	279	558	251	89.78%
8/29/2017	17-85027	435	Captive	17-87468	Captive	L162(15)CY	572	1,143	411	71.92%
8/29/2017	17-85027	435	Captive	17-87066	Captive	L162(15)CZ	572	1,143	411	71.92%
8/29/2017	6752939	420	Captive	17-87394	Captive	L163(15)DA	619	1,238	450	72.70%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/29/2017	6752939	420	Captive	17-87438	Captive	L163(15)DB	619	1,238	450	72.70%
8/29/2017	17-85620	420	Captive	17-87233	Captive	L164(15)DC	507	1,013	477	94.18%
8/29/2017	17-85620	420	Captive	17-87438	Captive	L164(15)DB	507	1,013	477	94.18%
8/30/2017	17-85732	400	Captive	17-87083	Captive	L165(15)DD	438	876	400	91.32%
8/30/2017	17-85732	400	Captive	17-87072	Captive	L165(15)DE	438	876	400	91.32%
8/30/2017	17-85089	510	Captive	17-87072	Captive	L166(15)DE	934	1,868	930	99.57%
8/30/2017	17-85089	510	Captive	17-87114	Captive	L166(15)DF	934	1,868	930	99.57%
8/30/2017	17-85600	440	Captive	17-87072	Captive	L167(15)DE	530	1,060	354	66.79%
8/30/2017	17-85600	440	Captive	17-87114	Captive	L167(15)DF	530	1,060	354	66.79%
8/30/2017	17-85795	460	Captive	17-87114	Captive	L168(15)DF	738	1,476	710	96.21%
8/30/2017	17-85795	460	Captive	17-85441	Captive	L168(14)DG	738	1,476	710	96.21%
8/30/2017	17-85841	440	Captive	17-85441	Captive	L169(14)DG	604	1,207	307	50.79%
8/30/2017	17-85841	440	Captive	17-86722	Captive	L169(15)DH	604	1,207	307	50.79%
8/30/2017	17-85832	465	Captive	17-85441	Captive	L170(14)DG	591	1,181	582	98.56%
8/30/2017	17-85832	465	Captive	17-86722	Captive	L170(15)DH	591	1,181	582	98.56%
8/30/2017	17-85757	440	Captive	17-87197	Captive	L171(15)DI	635	1,269	490	77.15%
8/30/2017	17-85757	440	Captive	17-87400	Captive	L171(15)DJ	635	1,269	490	77.15%
8/30/2017	17-85055	465	Captive	17-87197	Captive	L172(15)DI	703	1,406	684	97.30%
8/30/2017	17-85055	465	Captive	17-87400	Captive	L172(15)DJ	703	1,406	684	97.30%
8/30/2017	17-85991	510	Captive	17-87197	Captive	L173(15)DI	769	1,537	712	92.58%
8/30/2017	17-85991	510	Captive	17-87400	Captive	L173(15)DJ	769	1,537	712	92.58%
8/30/2017	17-85023	450	Captive	17-86814	Captive	L174(15)DK	807	1,614	752	93.18%
8/30/2017	17-85023	450	Captive	17-87284	Captive	L174(15)DL	807	1,614	752	93.18%
8/30/2017	17-85770	455	Captive	17-86814	Captive	L175(15)DK	693	1,386	686	98.92%
8/30/2017	17-85770	455	Captive	17-87284	Captive	L175(15)DL	693	1,386	686	98.92%
8/30/2017	17-85448	n/a	Captive	17-87284	Captive	L176(15)DL	464	927	452	97.52%
8/30/2017	17-85448	n/a	Captive	17-87166	Captive	L176(15)DM	464	927	452	97.52%
8/30/2017	17-85106	440	Captive	17-87166	Captive	L177(15)DM	647	1,293	625	96.67%
8/30/2017	17-85106	440	Captive	17-86816	Captive	L177(15)DN	647	1,293	625	96.67%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/30/2017	17-85022	440	Captive	17-87166	Captive	L178(15)DM	440	879	428	97.38%
8/30/2017	17-85022	440	Captive	17-86816	Captive	L178(15)DN	440	879	428	97.38%
8/30/2017	17-85300	480	Captive	17-86816	Captive	L179(15)DN	806	1,612	777	96.40%
8/30/2017	17-85300	480	Captive	17-86955	Captive	L179(15)DO	806	1,612	777	96.40%
8/30/2017	17-85452	470	Captive	17-86955	Captive	L180(15)DO	314	627	9	2.71%
8/30/2017	17-85452	470	Captive	17-85034	Captive	L180(14)DP	314	627	9	2.71%
8/30/2017	17-86048	435	Captive	17-86955	Captive	L181(15)DO	413	825	308	74.67%
8/30/2017	17-86048	435	Captive	17-85034	Captive	L181(14)DP	413	825	308	74.67%
8/30/2017	17-85737	450	Captive	17-85034	Captive	L182(14)DP	718	1,435	688	95.82%
8/30/2017	17-85737	450	Captive	17-87394	Captive	L182(15)DA	718	1,435	688	95.82%
8/30/2017	17-85458	370	Captive	17-85788	Captive	L183(14)CO	272	543	243	89.32%
8/30/2017	17-85458	370	Captive	17-87394	Captive	L183(15)DA	272	543	243	89.32%
8/30/2017	17-85758	450	Captive	17-85788	Captive	L184(14)CO	594	1,188	582	97.90%
8/30/2017	17-85758	450	Captive	17-87155	Captive	L184(15)DR	594	1,188	582	97.90%
8/30/2017	17-86171	390	Captive	17-87438	Captive	L185(15)DB	310	620	288	92.74%
8/30/2017	17-86171	390	Captive	17-87155	Captive	L185(15)DR	310	620	288	92.74%
8/30/2017	17-85041	440	Captive	17-87069	Captive	L186(15)DS	527	1,054	231	43.83%
8/30/2017	17-85041	440	Captive	17-86671	Captive	L186(15)DT	527	1,054	231	43.83%
8/30/2017	17-85344	440	Captive	17-87069	Captive	L187(15)DS	675	1,350	595	88.07%
8/30/2017	17-85344	440	Captive	17-86671	Captive	L187(15)DT	675	1,350	595	88.07%
8/30/2017	17-85048	510	Captive	17-87069	Captive	L188(15)DS	828	1,656	762	92.03%
8/30/2017	17-85048	510	Captive	17-86671	Captive	L188(15)DT	828	1,656	762	92.03%
8/30/2017	17-85964	360	Captive	17-85928	Captive	L189(14)DV	368	368	7	1.90%
8/30/2017	17-85708	405	Captive	17-85928	Captive	L190(14)DV	341	681	310	91.04%
8/30/2017	17-85708	405	Captive	17-87446	Captive	L190(15)DU	341	681	310	91.04%
8/30/2017	17-85614	490	Captive	17-87446	Captive	L191(15)DU	698	1,395	680	97.42%
8/30/2017	17-85614	490	Captive	17-85928	Captive	L191(14)DV	698	1,395	680	97.42%
8/30/2017	17-85002	450	Captive	17-87446	Captive	L192(15)DU	621	1,242	606	97.58%
8/30/2017	17-85002	450	Captive	17-85472	Captive	L192(14)DW	621	1,242	606	97.58%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/30/2017	17-85800	440	Captive	17-85472	Captive	L193(14)DW	738	1,476	712	96.48%
8/30/2017	17-85800	440	Captive	17-86697	Captive	L193(15)DX	738	1,476	712	96.48%
8/30/2017	17-85932	460	Captive	17-85472	Captive	L194(14)DW	662	1,323	642	97.05%
8/30/2017	17-85932	460	Captive	17-86697	Captive	L194(15)DX	662	1,323	642	97.05%
8/30/2017	17-85907	430	Captive	17-86697	Captive	L195(15)DX	487	973	476	97.74%
8/30/2017	17-85907	430	Captive	17-86714	Captive	L195(15)DY	487	973	476	97.74%
8/30/2017	17-85911	410	Captive	17-86714	Captive	L196(15)DY	540	1,079	442	81.84%
8/30/2017	17-85911	410	Captive	17-85983	Captive	L196(14)DZ	540	1,079	442	81.84%
8/30/2017	17-85533	420	Captive	17-86714	Captive	L197(15)DY	423	846	245	57.92%
8/30/2017	17-85533	420	Captive	17-85983	Captive	L197(14)DZ	423	846	245	57.92%
8/30/2017	17-85609	365	Captive	17-87219	Captive	L198(15)EA	256	512	92	35.74%
8/30/2017	17-85609	365	Captive	17-87235	Captive	L198(15)EB	256	512	92	35.74%
8/30/2017	17-86005	480	Captive	17-87219	Captive	L199(15)EA	1,018	2,035	1,000	98.23%
8/30/2017	17-86005	480	Captive	17-85983	Captive	L199(14)DZ	1,018	2,035	1,000	98.23%
8/30/2017	17-85274	440	Captive	17-87219	Captive	L200(15)EA	536	1,071	525	98.04%
8/30/2017	17-85274	440	Captive	17-87235	Captive	L200(15)EB	536	1,071	525	98.04%
8/30/2017	17-85359	470	Captive	17-87235	Captive	L201(15)EB	752	1,504	195	25.93%
8/30/2017	17-85359	470	Captive	17-87177	Captive	L201(15)EC	752	1,504	195	25.93%
8/30/2017	17-85863	450	Captive	17-87181	Captive	L202(15)ED	683	1,365	632	92.60%
8/30/2017	17-85863	450	Captive	17-87199	Captive	L202(15)EE	683	1,365	632	92.60%
8/30/2017	17-85559	470	Captive	17-87181	Captive	L203(15)ED	312	624	123	39.26%
8/30/2017	17-85559	470	Captive	17-87306	Captive	L203(15)EF	312	624	123	39.26%
8/30/2017	17-85926	450	Captive	17-87181	Captive	L204(15)ED	363	726	304	83.75%
8/30/2017	17-85926	450	Captive	17-87306	Captive	L204(15)EF	363	726	304	83.75%
8/30/2017	17-85927	420	Captive	17-87306	Captive	L205(15)EF	447	894	434	97.09%
8/30/2017	17-85927	420	Captive	17-85511	Captive	L205(14)EG	447	894	434	97.09%
8/30/2017	17-85799	440	Captive	17-86619	Captive	L206(15)EH	627	1,254	487	77.67%
8/30/2017	17-85799	440	Captive	17-87276	Captive	L206(15)EI	627	1,254	487	77.67%
8/30/2017	17-85239	380	Captive	17-85511	Captive	L207(14)EG	224	447	135	60.18%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
8/30/2017	17-85239	380	Captive	17-87276	Captive	L207(15)EI	224	447	135	60.18%
8/30/2017	17-86167	430	Captive	17-86619	Captive	L208(15)EH	647	1,294	593	91.65%
8/30/2017	17-86167	430	Captive	17-87276	Captive	L208(15)EI	647	1,294	593	91.65%
8/31/2017	17-85197	480	Captive	17-86619	Captive	L209(15)EH	583	1,166	563	96.57%
8/31/2017	17-85197	480	Captive	17-86798	Captive	L209(15)EJ	583	1,166	563	96.57%
8/31/2017	17-85988	430	Captive	17-87233	Captive	L210(15)DC	538	1,076	504	93.68%
8/31/2017	17-85988	430	Captive	17-86798	Captive	L210(15)EJ	538	1,076	504	93.68%
8/31/2017	17-85622	430	Captive	17-86798	Captive	L211(15)EJ	224	224	9	4.02%
8/31/2017	17-85409	390	Captive	17-87233	Captive	L212(15)DC	528	1,056	336	63.64%
8/31/2017	17-85409	390	Captive	17-87311	Captive	L212(15)EK	528	1,056	336	63.64%
8/31/2017	17-85875	440	Captive	17-87311	Captive	L213(15)EK	593	1,185	539	90.97%
8/31/2017	17-85875	440	Captive	17-86658	Captive	L213(15)EL	593	1,185	539	90.97%
8/31/2017	17-85204	430	Captive	17-87311	Captive	L214(15)EK	478	955	232	48.48%
8/31/2017	17-85204	430	Captive	17-86658	Captive	L214(15)EL	478	955	232	48.48%
8/31/2017	17-85733	430	Captive	17-87126	Captive	L215(15)EM	556	1,111	455	81.91%
8/31/2017	17-85733	430	Captive	17-87258	Captive	L215(15)EN	556	1,111	455	81.91%
9/6/2017	17-85389	410	Captive	17-87216	Captive	L216(15)EO	464	928	454	97.74%
9/6/2017	17-85389	410	Captive	17-87091	Captive	L216(15)EP	464	928	454	97.74%
9/6/2017	503360694A	440	Captive	17-87216	Captive	L217(15)EO	502	1,003	459	91.53%
9/6/2017	503360694A	440	Captive	17-87091	Captive	L217(15)EP	502	1,003	459	91.53%
9/6/2017	17-85899	450	Captive	17-87247	Captive	L218(15)EQ	704	1,407	695	98.79%
9/6/2017	17-85899	450	Captive	17-87541	Captive	L218(15)ER	704	1,407	695	98.79%
9/6/2017	17-85113	395	Captive	17-87247	Captive	L219(15)EQ	430	859	371	86.26%
9/6/2017	17-85113	395	Captive	17-87541	Captive	L219(15)ER	430	859	371	86.26%
9/6/2017	17-86173	400	Captive	17-86530	Captive	L220(15)ES	498	995	371	74.57%
9/6/2017	17-86173	400	Captive	17-86916	Captive	L220(15)ET	498	995	371	74.57%
9/6/2017	17-85829	470	Captive	17-86530	Captive	L221(15)ES	720	1,439	677	94.09%
9/6/2017	17-85829	470	Captive	17-86916	Captive	L221(15)ET	720	1,439	677	94.09%
9/6/2017	17-85174	430	Captive	17-87461	Captive	L222(15)EU	259	518	181	69.69%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
9/6/2017	17-85174	430	Captive	17-87472	Captive	L222(15)EV	259	518	181	69.69%
9/6/2017	17-85815	420	Captive	17-87461	Captive	L223(15)EU	453	905	423	93.48%
9/6/2017	17-85815	420	Captive	17-85511	Captive	L223(14)EG	453	905	423	93.48%
9/6/2017	17-85948	450	Captive	17-87240	Captive	L224(15)EW	452	903	448	99.22%
9/6/2017	17-85948	450	Captive	17-87126	Captive	L224(15)EM	452	903	448	99.22%
9/6/2017	17-85830	420	Captive	17-86548	Captive	L225(15)EX	433	866	392	90.53%
9/6/2017	17-85830	420	Captive	17-87489	Captive	L225(15)EY	433	866	392	90.53%
9/6/2017	17-85373	500	Captive	17-86548	Captive	L226(15)EX	835	1,670	807	96.65%
9/6/2017	17-85373	500	Captive	17-87489	Captive	L226(15)EY	835	1,670	807	96.65%
9/6/2017	17-85431	410	Captive	17-87165	Captive	L227(15)EZ	294	588	284	96.60%
9/6/2017	17-85431	410	Captive	17-87336	Captive	L227(15)FA	294	588	284	96.60%
9/6/2017	17-85652	440	Captive	17-87165	Captive	L228(15)EZ	386	771	262	67.96%
9/6/2017	17-85652	440	Captive	17-87336	Captive	L228(15)FA	386	771	262	67.96%
9/6/2017	17-85354	500	Captive	17-87154	Captive	L229(15)FB	852	1,704	787	92.37%
9/6/2017	17-85354	500	Captive	17-87258	Captive	L229(15)EN	852	1,704	787	92.37%
9/6/2017	17-85636	410	Captive	17-87154	Captive	L230(15)FB	492	983	485	98.58%
9/6/2017	17-85636	410	Captive	17-87371	Captive	L230(15)FC	492	983	485	98.58%
9/6/2017	17-85734	400	Captive	17-87371	Captive	L231(15)FC	382	763	254	66.45%
9/6/2017	17-85734	400	Captive	17-86767	Captive	L231(15)FD	382	763	254	66.45%
9/6/2017	17-85186	440	Captive	17-86767	Captive	L232(15)FD	554	1,107	546	98.64%
9/6/2017	17-85186	440	Captive	17-86811	Captive	L232(15)FE	554	1,107	546	98.64%
9/6/2017	17-85229	410	Captive	17-86811	Captive	L233(15)FE	283	283	61	21.55%
9/6/2017	17-86018	450	Captive	17-87066	Captive	L234(15)CZ	574	1,147	531	92.50%
9/6/2017	17-86018	450	Captive	17-87298	Captive	L234(15)FF	574	1,147	531	92.50%
9/6/2017	17-85893	410	Captive	17-86832	Captive	L235(15)FG	371	741	44	11.88%
9/6/2017	17-85893	410	Captive	17-87336	Captive	L235(15)FA	371	741	44	11.88%
9/12/2017	17-85509	460	Captive	17-86767	Captive	L236(15)FD	601	1,202	570	94.84%
9/12/2017	17-85509	460	Captive	17-87371	Captive	L236(15)FC	601	1,202	570	94.84%
9/12/2017	17-85085	375	Captive	17-86832	Captive	L237(15)FG	399	797	330	82.81%

TABLE 1.—Continued.

Spawn Date	Female ID number	Female Length (mm)	Female Origin	Male ID number	Male Origin	Family Group ID	Green eggs Per cross	Green eggs Per female	Eyed Eggs	Percent Eyed Eggs
9/12/2017	17-85085	375	Captive	17-87066	Captive	L237(15)CZ	399	797	330	82.81%
9/12/2017	17-85383	470	Captive	17-80181	Cryo	L238(cryo)BH	674	674	304	45.10%
9/12/2017	17-85383	470	Captive	17-80192	Cryo	L238(cryo)BI	645	645	1	0.16%
9/12/2017	17-85491	455	Captive	17-87066	Captive	L239(15)CZ	595	1,190	581	97.56%
9/12/2017	17-85491	455	Captive	17-87154	Captive	L239(15)FB	595	1,190	581	97.56%
9/12/2017	17-85653	480	Captive	17-86832	Captive	L240(15)FG	936	1,872	907	96.85%
9/12/2017	17-85653	480	Captive	17-87371	Captive	L240(15)FC	936	1,872	907	96.85%
9/12/2017	17-85913	360	Captive	17-87154	Captive	L241(15)FB	404	404	240	59.41%
9/19/2017	17-85100	450	Captive	17-86975	Captive	L242(15)FH	595	1,190	72	12.02%
9/19/2017	17-85100	450	Captive	17-85983	Captive	L242(14)DZ	595	1,190	72	12.02%
9/19/2017	17-85387	430	Captive	17-86975	Captive	L243(15)FH	575	1,149	549	95.56%
9/19/2017	17-85387	430	Captive	17-87014	Captive	L243(15)CW	575	1,149	549	95.56%
9/19/2017	17-85914	390	Captive	17-87489	Captive	L244(15)EY	383	766	361	94.13%
9/19/2017	17-85914	390	Captive	17-86975	Captive	L244(15)FH	383	766	361	94.13%

TABLE 2.—Relevant early life history dates and count summary of brood year 2017 winter Chinook Salmon captive broodstock progeny produced at the Livingston Stone National Fish Hatchery and transferred for rearing to the Coleman National Fish Hatchery (CNFH).

						Number Eyed Eggs		Date Transferred	Life Stage at
Lot	Take	Date Spawned	Date Eyed	Date Hatched	Date Tanked	Take	Lot	to CNFH	Transfer
1	1	7/25/2017	8/24/2017	9/8/2017	10/3/2017	2,938		10/18/2017	Button-up Fry
	2	7/31/2017	8/30/2017	9/14/2017	10/9/2017	4,798		10/18/2017	Button-up Fry
	3	8/2/2017	9/1/2017	9/16/2017	10/11/2017	862		10/11/2017	Button-up Fry
	4	8/3/2017	9/2/2017	9/17/2017	10/12/2017	3,340		10/11/2017	Button-up Fry
	5	8/7/2017	9/6/2017	9/21/2017	10/16/2017	5,831		10/16/2017	Button-up Fry
	6	8/8/2017	9/7/2017	9/22/2017	10/17/2017	4,919		10/16/2017	Button-up Fry
	7	8/9/2017	9/8/2017	9/23/2017	10/18/2017	13,335	36,023	10/16/2017	Button-up Fry
2	8	8/15/2017	9/14/2017	9/29/2017	10/24/2017	20,715		10/25/2017	Button-up Fry
	9	8/16/2017	9/15/2017	9/30/2017	10/25/2017	7,908		10/25/2017	Button-up Fry
	10	8/17/2017	9/16/2017	10/1/2017	10/26/2017	10,431	39,054	10/25/2017	Button-up Fry
3	11	8/23/2017	9/22/2017	10/7/2017	11/1/2017	37,954	37,954	11/2/2017	Button-up Fry
4	12	8/24/2017	9/23/2017	10/8/2017	11/2/2017	33,107	33,107	11/2/2017	Button-up Fry
5	13	8/25/2017	9/24/2017	10/9/2017	11/3/2017	16,001		11/2/2017	Button-up Fry
	14	8/29/2017	9/28/2017	10/13/2017	11/7/2017	18,802	34,803	11/7/2017	Button-up Fry
6	15	8/30/2017	9/29/2017	10/14/2017	11/8/2017	42,446	42,446	10/11/2017	Eyed Egg
7	16	8/31/2017	9/30/2017	10/15/2017	11/9/2017	5,266		10/12/2017	Eyed Egg
	17	9/6/2017	10/6/2017	10/21/2017	11/15/2017	16,997		10/12/2017	Eyed Egg
	18	9/12/2017	10/12/2017	10/27/2017	11/21/2017	5,319		10/12/2017	Eyed Egg
	19	9/19/2017	10/19/2017	11/3/2017	11/28/2017	1,962	29,544	10/18/2017	Eyed Egg

TABLE 3.—Estimated rates of mark-tag retention and numbers (in parenthesis) of winter Chinook released with various combinations of marks and tags, based on sampling conducted >21-days after marking and tagging.

CWT Code	Estimated rates and numbers with various combinations of marks and tags[1] C/T pelvic	C/T no pelvic	C/NT pelvic	NC/T pelvic	NC/NT pelvic	Total
050687	99.0%	0.5%	0.5%	0.0%	0.0%	
	(29,719)	*(149)*	*(149)*	*(0)*	*(0)*	*(30,017)*
052579	99.5%	0.0%	0.5%	0.0%	0.0%	
	(26,724)	(0)	(134)	(0)	(0)	(26,858)
052580	99.5%	0.0%	0.0%	0.0%	0.5%	
	(25,122)	*(0)*	*(0)*	*(0)*	*(126)*	*(25,248)*
056173	100.0%	0.0%	0.0%	0.0%	0.0%	
	(29,947)	(0)	(0)	(0)	(0)	(29,947)
056174	99.0%	0.0%	0.5%	0.0%	0.5%	
	(32,177)	*(0)*	*(163)*	*(0)*	*(162)*	*(32,502)*
056175	98.5%	0.0%	0.5%	0.0%	1.0%	
	(32,600)	*(0)*	*(165)*	*(0)*	*(331)*	*(33,096)*
056176	99.5%	0.0%	0.0%	0.5%	0.0%	
	(37,340)	*(0)*	*(0)*	*(188)*	*(0)*	*(37,528)*

[1] C = fish with an adipose-fin clip, NC = fish with no adipose-fin clip, T = fish with a coded-wire tag, NT = fish with no coded-wire tag, pelvic = fish with a pelvic-fin clip, and no pelvic = fish with no pelvic-fin clip.

TABLE 4.—Summary of release data for brood year 2017 winter Chinook Salmon captive broodstock progeny.

Release Group	Release Date	CWT Code	Release Number	Fork Length (mm) *mean (min – max, SD)*
1	3/2/2018	06 61 73	29,947	80 (45 – 94, 6.1)
2	3/14/2018	05 25 79	26,858	74 (59 – 86, 4.7)
		05 61 74	32,502	78 (55 – 90, 5.8)
		05 61 75	33,096	74 (54 – 89, 5.3)
3	3/16/2018	05 06 87	30,017	72 (57 – 84, 4.1)
		05 61 76	37,528	71 (49 – 84, 5.2)
4	4/6/2018	05 25 80	25,248	79 (56 – 92, 5.2)
			215,047	

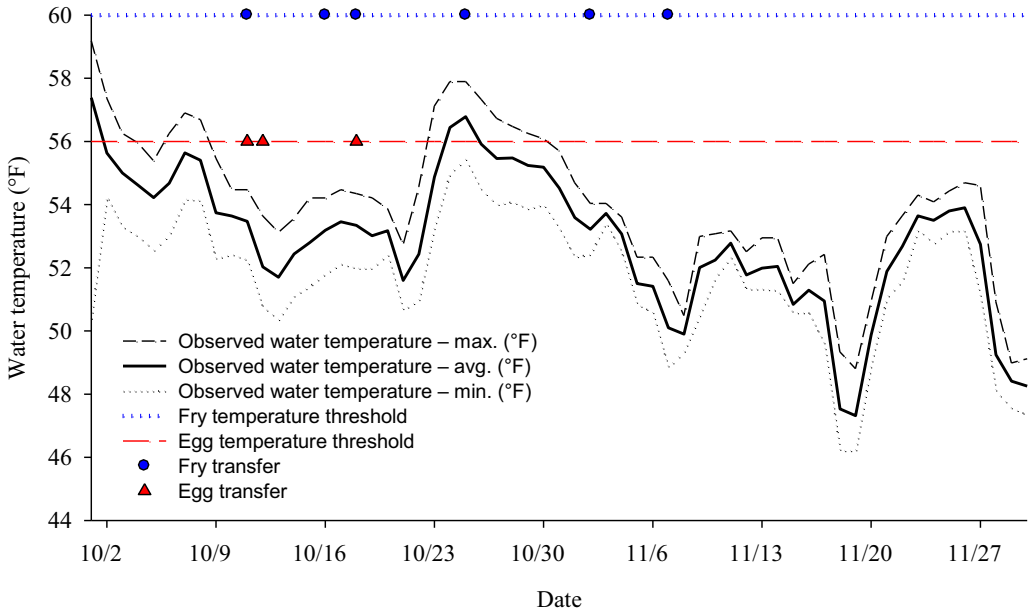

FIGURE 1.—Daily water temperature profile for the Coleman NFH from October 1 to November 30, 2017. The temperature thresholds for transferring eggs and fry from the Livingston Stone National Fish Hatchery to the Coleman National Fish Hatchery are presented and include actual dates of transfer.

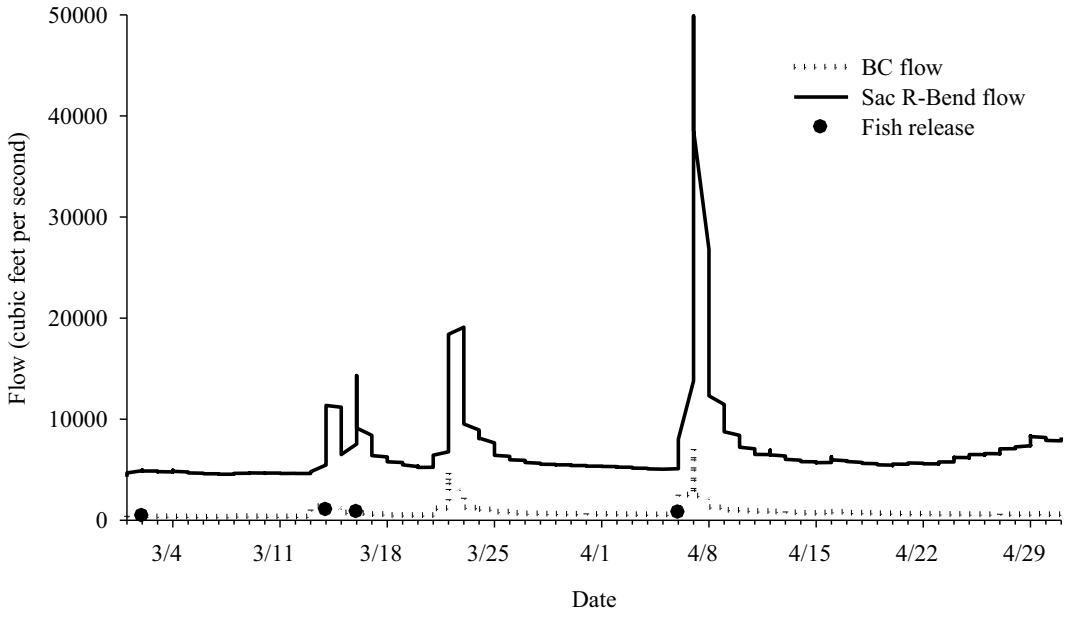

FIGURE 2.—Measured rate of flow, cubic feet per second, on Battle Creek near the Coleman National Fish Hatchery and on the Sacramento River at Bend Bridge from March 1 to May 2, 2018 (https://waterdata.usgs.gov/ca/nwis/uv). Fish release dates are also indicated for each of the winter Chinook Salmon events.

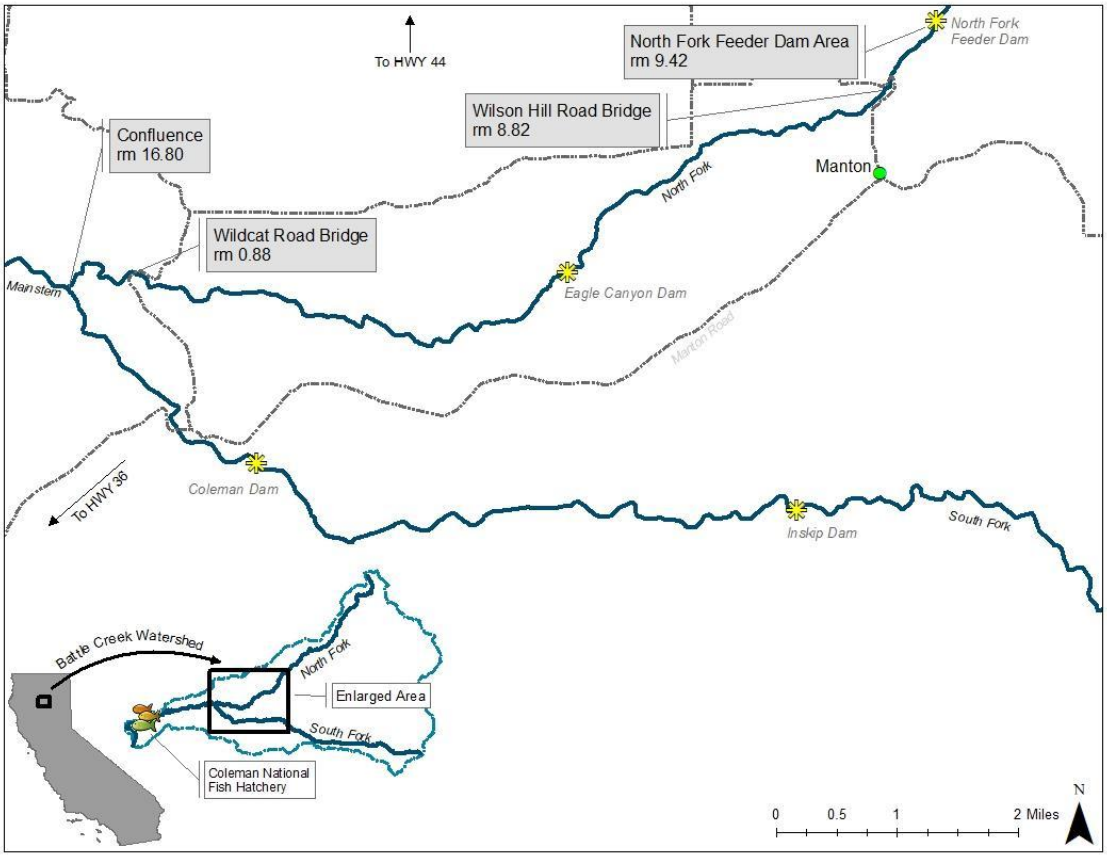

FIGURE 3.—Map of the North Fork Battle Creek section containing the three proposed winter Chinook Salmon captive progeny release sites.

ATTACHMENT 1.—Fish Health Inspection Report for captive winter Chinook Salmon broodstock, and their progeny, contributing to the brood year 2017 release group.

DEPARTMENT OF THE INTERIOR
U.S. Fish and Wildlife Service
FISH HEALTH INSPECTION REPORT[1]
This report is NOT evidence of future disease status. To determine status, contact the inspecting biologist below.

Fish Source & Facility Contact	Fish Examined	Water Supply[2]	5 year facility classification
Livingston Stone NFH 16349 Shasta Dam Blvd Shasta Lake, CA 96019 (Area Code) (530) 275-0549 Number Alvin Duncan, Assistant Hatchery Manager	☑ Hatchery ☐ Wild	☑ Unsecured: Open Spring, Stream ☑ Secured: Well, sterilized	Last sample date / Classification 1 2/5/2018 cJuveniles — No pathogens detected 2 10/13/2017 cBY14/15 — OF: No pathogens detected 3 6/7/2017 cBY14/15 — No pathogens detected 4 None — No pathogens detected 5

Species[3]	Lot Identity	Age[4]	# in lot	Eggs (E) or fish (F) Obtained From	Pathogens inspected[3] & results'[5]													
					EI	AS	YR	RS	MC	IH	IP	IS	LM	OM	SV	VH	A	B
WCS	Juveniles	6mo	215,000	E - Captive BY14 &15	NT	60	60	30	NT	60	60	60	NT	60	NT	60		
					NA	-	-	-	NA	-	-	-	NAT	-	NA	-		
WCS	Captive BY14	3yr	524	E-Sacramento River	NT	60	60	60	60	60	60	60	NT	60	NT	60		
					NA	-	-	-	-	-	-	-	NA	-	NA	-		
WCS	Captive BY15	2yr	1020	E-Sacramento River	NT	27	27	27	30	30	30	30	NT	30	NT	30		
					NA	-	-	-	-	-	-	-	NA	-	NA	-		
WCS	Captive BY14/15	2-3yr		E-Sacramento River														
				Ovarian Fluid 30, 1-p				30										
								-										

Remarks[6]:

Inspecting Biologist Signature	Concurred (signature & title)	
Kimberly True Print: Kimberly True Date: 02/23/2018	Print: Date:	California-Nevada Fish Health Center 24411 Coleman Fish Hatchery Rd Anderson, CA 96007 (Area Code) (530) 365-4271 Number

[1] Done in accordance with the AFS Fish Health Section Bluebook *Suggested Procedures for the Detection and Identification of Certain Finfish and Shellfish Pathogens* and the U.S. Fish and Wildlife Service Fish Health Policy 713 FW 1-5. [2] Secure = free of all aquatic pathogens or sterilized, Unsecured = aquatic pathogens may be present. [3] FWS abbreviations (see back of this page), [4] For hatchery fish give age in months; for feral fish, use symbols: e=eggs or fry; f=fingerling; y=yearlings; b=older fish. [5] Findings reported as number examined over results; (-) = undetected, (+) = positive, and NT= not tested, A,B = other pathogens as listed in remarks[6] Additional remarks can be made on back page.

DEPARTMENT OF THE INTERIOR
U.S. Fish and Wildlife Service
FISH HEALTH INSPECTION REPORT[1]
This report is NOT evidence of future disease status. To determine status, contact the inspecting biologist below.

Additional Inspection Information
Laboratory Case Number:

1) Fish Health Inspection Report for WCS progeny of Captive WCS Broodstock, transfered to Coleman NFH as eggs and yolk-fry for Battle Creek Jumpstart Program (BC Restoration Program). Juvenile WCS reared at CNFH (Case Number 18-034) were examined on 2/5/18. Kd/Spln/Lvr/Gill samples were collected from 60 fish and tested for Virology (18 days), culturable bacteria and R.salmoninarum by QPCR.
Methods: Virology (VE, VH, VP): Inoculation and a minimum of 18 days incubation and on both EPC and CHSE-214 cell lines. Aeromonas salmonicida (AS) and Yersinia ruckeri (YR) assayed by direct culture of tissue on appropriate media and biochemical tests. Renibacterium salmoninarum (RS) assayed by QPCR on 6,5-pool KD tissue.

2) Included on this form is prior Fish Health Inspection Report for Captive Winter-run Chinook Salmon Broodstock BY14 and BY 15 (Case Numbers 17-056 & 17-057), held at Livingston Stone NFH. Adults were sampled on 6/7/2017: BY14 consisted of mixed males and females, for BY15 only males were samples.

3) Included on this form is supplemental testing results for additional R.salmoninarum. testing of Captive Broodstock BY14/15 held at Livingston Stone NFH (Case Number 18-003). Ovarian Fluid samples were submitted for Rs-QPCR testing after all BY14/15 females were spawned. Samples rec'd 10/13/17.

PATHOGEN ABBREVIATIONS	SPECIES ABBREVIATIONS			
AS Aeromonas salmonicida EI Edwardsiella ictaluri RS Renibacterium salmoninarum YR Yersinia ruckeri MC Myxobolus cerebralis IH Infectious Hematopoietic Necrosis Virus IP Infectious Pancreatic Necrosis Virus IS Infectious Salmon Anemia Virus LM Largemouth Bass Virus OM Oncorhynchus masou Virus SV Spring Viremia of Carp Virus VH Viral Hemorrhagic Septicemia Virus	Amur Pike AMP Apache Trout APT Arctic Grayling ARG Atlantic Salmon ATS Beautiful Shiner GBS Big Bend Gambusia BBG Bigmouth Buffalo BIB Black Bullhead BLB Black Crappie BLC Blue Catfish BCF Blue X Channel BCFCCF Bluegill BLG Blue Pike BLP Bluntnose Shiner PBS Bonytail Chub BTC Bowfin BON Brook Trout BKT Brown Bullhead BRB Brown Trout BNT Carp CAP Channel Catfish CCF Chihuahua Chub CCH Chum Salmon CHS Coho Salmon COS	Colorado Pikeminnow CPM Comanche Springs pupfish CSP Cutthroat Trout CUT Darters DAR Desert Pupfish DEP Desert Sucker DES Devils Hole Pupfish DHP Dolly Varden DOV Dolly Varden X BKT DOVBKT Fall Chinook Salmon FCS Fathead Minnow FHM Flathead Catfish FCF Freshwater Drums FRD Gars GAR Gila Topminnow GTM Gila Trout GIT Golden Shiner GOS Golden Trout GOT Goldfish GOF Grass Carp GRC Green Sunfish GSF Guadalupe Bass GUB Herrings HEG Killifishes KIH	Kokanee KUE Landlocked ATS LAS Leon Springs pupfish LSP Lake Trout LAT Lampreys LAY Largemouth Bass LMB Livebearers LIR Miscellaneous Warm Water MSC Mooneyes MOE Mudminnows MUW Muskellunge MUE Northern Pike NOP Ohrid Trout OHT Other Catfishes OCF Other Minnows OTM Other Pikes OTP Other Salmonids OSA Other Suckers OTS Other Sunfishes OSF Paddlefish PAH Pahranagat Roundtail Chub PRC Pecos Gambusia PEG Pink Salmon PKS Rainbow Trout RBT	Rainbox Trout X Steelhead RBTSTT Razorback Sucker RBS Redear Sunfish RSF Rio Grande Silvery Minnow RGSM Sanora Sucker SOS Sauger SAR Smallmouth Buffalo SAB Silver Carp SVC Smallmouth Bass SMB Sockeye Salmon SOS Spotted Bass SPB Spring Chinook Salmon SCS Steelhead Trout STT Sticklebacks STK Striped Bass STB Sturgeons STN Virgin Chub VRC Walleye WAE Walleye X Sauger WAESAR Warmouth WAM White Catfish WCF Winter Chinook Salmon WCS Woundfin WDF

ATTACHMENT 2.—Fish Health Diagnostic Report and Pathology Report for brood year 2014 winter Chinook Salmon captive broodstock contributing to the brood year 2017 Jumpstart release group into Battle Creek

Fish Health Diagnostic Report

US Fish and Wildlife Service
California-Nevada Fish Health Center
24411 Coleman Fish Hatchery Rd
Anderson, CA 96007

CA-NV FHC Case #16-118
Submitted by: Kim True
Sample Site(s): LSNFH
Species: BY 2014 Captive Broodstock

Sample Date: 9/12/16
Date Received: 9/12/16
Report Date: 9/20/16
Examined by: Kim True, Scott Foott (histology)

Purpose of Examination:
Diagnose rapid mortality increase in BY14 Captive Winter-run (Male Circular Tank CB5).
Elevated mortality reported to FHC Monday morning (9/12/16). High loss of male 2 yr old captives over past 5 days (50 per day on 9/11 and 9/12).

Examination Methods and Notes:
Several male fish were moribund, swimming high and covered in heavy fungal infections (*Saprolegnia*). Males were actively expressing milt with minimal handling and testes were found to be sexually mature on dissection in most fish sampled. Gills appeared mottled with several small to large necrotic lesions.

Sampled 3 moribund and 3 fresh mortality males at LSNFH. Imprints of gill, kidney, spleen and testis (one male) were taken. Multiple tissues fixed in Davidson's for histological exam. Another 3 moribund males taken back to lab for staining and microscopic examination of gills.

BY2014 Captives were moved August 23 from CB1&2 to clean tanks CB4&5. Tank hygiene on last visit (August 12) was very poor; particularly tank CB1 which was located under active osprey nest.

Assay	Tissue	# Samples
Wet mounts	Gill	3
Tissue Imprints / Gram Stain	Gill, Kidney, Spleen	9
Histology (Davidson's fixative)	Gill, Kd/Lvr, Testes	4

Significant Findings:
Bacterial Gill Disease by gill imprint (9/9). Heavy infections of long filamentous bacteria, areas of necrosis and large accumulation of debris. Confirmed BGD by histology (4/4) and associated osmotic failure evident in liver and kidney tissues by histology (see attached histology pathology report). Fungal skin infections associated with immunosuppression and sexual maturity.

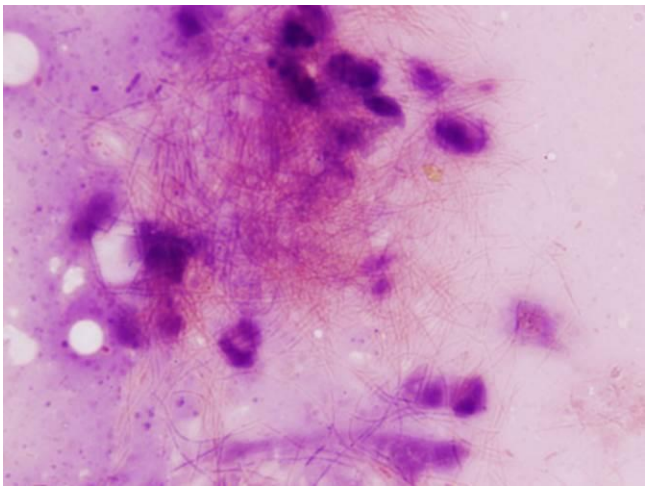

Figure 1 and 2. Gill Necrosis/lesions and filamentous bacterial infections in moribund males.

Figure 3. Fungal infections. Middle fish was not sexually mature, and fungal infection was less severe than in the sexually mature males.

Recommendations:

Move males to adult holding tank and treat with malachite for BGD and fungus.

Treat female tanks with 3% salt. FHC will check female gills this week and recheck a small number of males following malachite treatment.

Clean captive circular tanks weekly. When males are sexually mature (actively expressing milt) use some discretion on cleaning schedule to minimize stress but maintain good tank hygiene.

PATHOLOGY REPORT

US Fish & Wildlife Service
CA-NV Fish Health Center
24411 Coleman Hatchery Rd
Anderson, CA 96007

phone 530-365-4271
fax 530-365-7150

FHC Case No. **: 16-118** Submittal date: **9-12-2016**
Sample Collector**: K True** Sample Site(s): **Livingston Stone NFH**
Histological specimen examiner: **J. Scott Foott**
Species:WCS Age**: BY2014 male captives**
Tissues: **KD LV GILL DISTAL INTES teste**
3 moribund fish sampled at LS NFH, 2 fish brought back to FHC, dead at time of sample

Fixative: **Davidson (xx) , PREFER-ETOH (), 10%BF ( ), ZFIX ( ), Bouins ( )**
Stains: **Hematoxylin & eosin (xxx), PAS ( ), Iron ( ) ACID FAST () Gram ()**
Block No**. 9505-9510** Block / slide deposition: **FHC**
Blood Smear (Number): **ND** Bloodsmear Stain**: Lieshman-Giemsa ( ), DiffQuick( )**
Clinical chemistry: **ND**

Summary

- Clinical Bacterial Gill Disease observed in 4 of 4 gill sections, multifocal lamellar hyperplasia and necrosis associated with bacteria
- Osmotic failure evident from marked enlargement of sinuses in liver and bowman's capsule in kidney
- Mature males evident from presence of spermatozoa, observed thicken glomerular mesangium also common in mature males
- Fungal skin lesions likely associated with testosterone immunosuppression as well as tank conditions (build up of zoospores).

Spleen(2) – higher than normal ratio of connective tissue to blood cell indicative of leukocyte depletion
Distal intestine XC (3) - normal