Shasta Crayfish (*Pacifastacus fortis*)

5-Year Review:
Summary and Evaluation

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U.S. Fish and Wildlife Service
Sacramento Fish and Wildlife Office
Sacramento, California

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5-YEAR REVIEW

Shasta Crayfish (*Pacifastacus fortis*)

I. GENERAL INFORMATION

Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview:

As summarized from the Recovery Plan for this species (Service 1998), Shasta crayfish (*Pacifastacus fortis*) are 2-4 inches in length (from tip of claw to end of tail) with a dark brown back and a bright read-orange underside. It is restricted to the midsections of the Pit River drainage in Shasta County, California. Overall Shasta crayfish populations have low abundance and fragmented distribution. The migration, and therefore genetic exchange, between populations is limited by hydroelectric development, natural barriers, and habitat loss. The cool, clear, spring-fed headwaters with clean volcanic cobbles on top of gravel or sand characterize this species required habitat. The main threats to Shasta crayfish include the introduction and expansion of non-native crayfish (signal crayfish (*Pacifastacus leniusculus*) and fantail crayfish (*Orconectes virilis*)), nonnative fish, and habitat disturbances related to land use practices.

Methodology Used to Complete This Review:

This review was prepared by the Sacramento Fish and Wildlife Office (SFWO), following the Region 8 guidance issued in March 2008. We used information from the Recovery Plan and survey information from experts who have been monitoring various localities of this species. The Recovery Plan and personal communications with experts were our primary sources of information used to update the species' status and threats. We received two responses, an email from Maria Ellis, the leading expert on Shasta crayfish, and a letter from the California State Attorney General's Office in response to our Federal Register Notice initiating this 5-year review.

This 5-year review contains updated information on the species' biology and threats, and an assessment of that information compared to that known at the time of listing or since the last 5-year review. We focus on current threats to the species that are attributable to the Act's five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

Contact Information:

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Lead Field Office: Kirsten Tarp, Recovery Branch, Sacramento Fish and Wildlife Office; (916) 414-6660.

Federal Register (FR) Notice Citation Announcing Initiation of This Review: A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register on March 5, 2008 (Service 2008). The Service received two responses. One response specific to the Shasta crayfish and a second response regarding all 58 species covered in the notice. We have considered these responses in preparing this 5-year review.

Listing History:

Original Listing
FR Notice: 53 FR 38460-38465
Date of Final Listing Rule: September 30, 1988
Entity Listed: Crayfish, Shasta (=placid) (*Pacifastacus fortis*), a listed crustacean
Classification: Endangered

State Listing
Shasta crayfish (= placid crayfish) was listed by the State of California as threatened in 1980. The State of California revised the Shasta crayfish designation to endangered in 1988.

Associated Rulemakings: The Shasta crayfish has not had critical habitat designated, nor does it have any other special rule.

Review History:
This review is the first status review conducted on this species since it was listed in 1988.

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for Shasta crayfish is 5 according to the Service's 2008 Recovery Data Call for the Sacramento

Fish and Wildlife Office based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Service 1983). This number indicates that the taxon is a *species* that faces *a high degree of threat* and has a *low probability* for recovery.

Recovery Plan

Name of Plan: Recovery Plan for the Shasta Crayfish (*Pacifastacus fortis*)
Date Issued: August 28, 1998

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy

The Endangered Species Act defines "species" as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. Because the species under review is an invertebrate, the DPS policy is not applicable, and the application of the DPS policy to the species' listing is not addressed further in this review.

Information on the Species and its Status

Species Biology and Life History
Shasta crayfish are long-lived and slow-growing, with an estimated life span of 10-15 years. Reproductive maturity is slow, usually in the fifth year of life. In general, crayfish fecundity increases with age, thus young females produce fewer eggs that older females, with an average of 40 eggs per female. Shasta crayfish mate in October and a female can only produce one clutch of eggs per year, which she attaches to the underside of her abdomen or tail. The eggs hatch in spring and remain attached to their mother through the third molt and then slowly become free living.

Shasta crayfish tend to be solitary, but will tolerate other crayfish if cover habitat is limited. Shasta crayfish are extremely nocturnal, remaining completely hidden during daylight hours. They leave protective cover only after dark. Little is known of the exact diet of Shasta crayfish but it appears to be a carnivore or browser rather than an omnivorous scavenger. Food sources may include periphyton (mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged surfaces) and invertebrates such as snails (Eng and Daniels 1982).

Spatial Distribution
Although it is impossible to determine the exact historical range and distribution of the Shasta crayfish, due to its narrow habitat requirements (i.e. cold, clear spring water and rocky substrate), we are fairly confident that the Shasta crayfish has always been restricted to the Pit River drainage in northeastern California (Eng and Daniels 1982). The current and historical ranges include the Fall River, Tule River, Pit River (upstream of Fall River Mills), Hat Creek (downstream for the confluence of Rising River) and Rising River in northeastern Shasta County, California (Figure 1). The limits of its range appear to be relatively unchanged. While

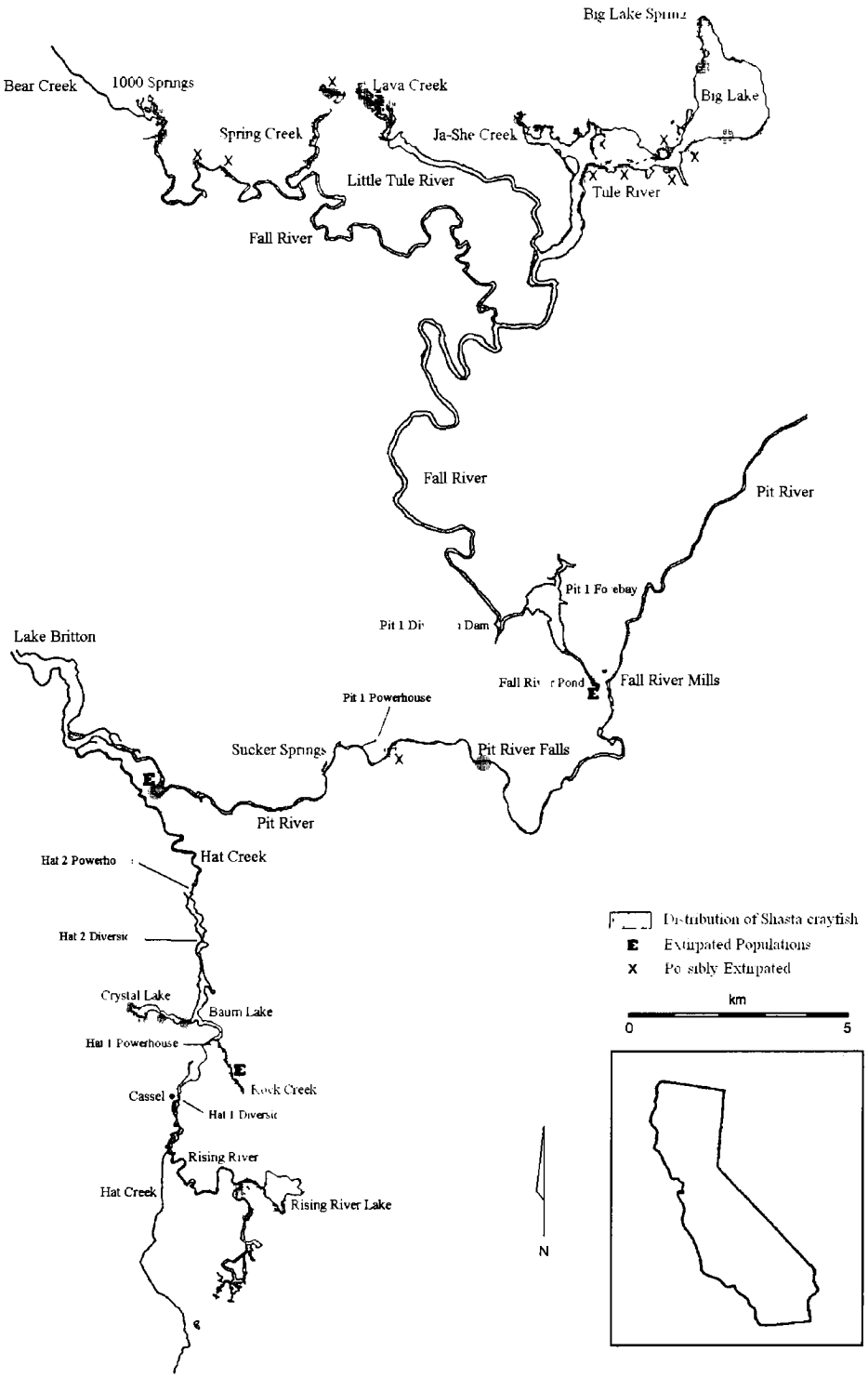

Figure 1. Current and Historic Range of Shasta Crayfish depicting locations of currently occupied and extirpated (or believed extirpated) subpopulations (Spring Rivers 2007).

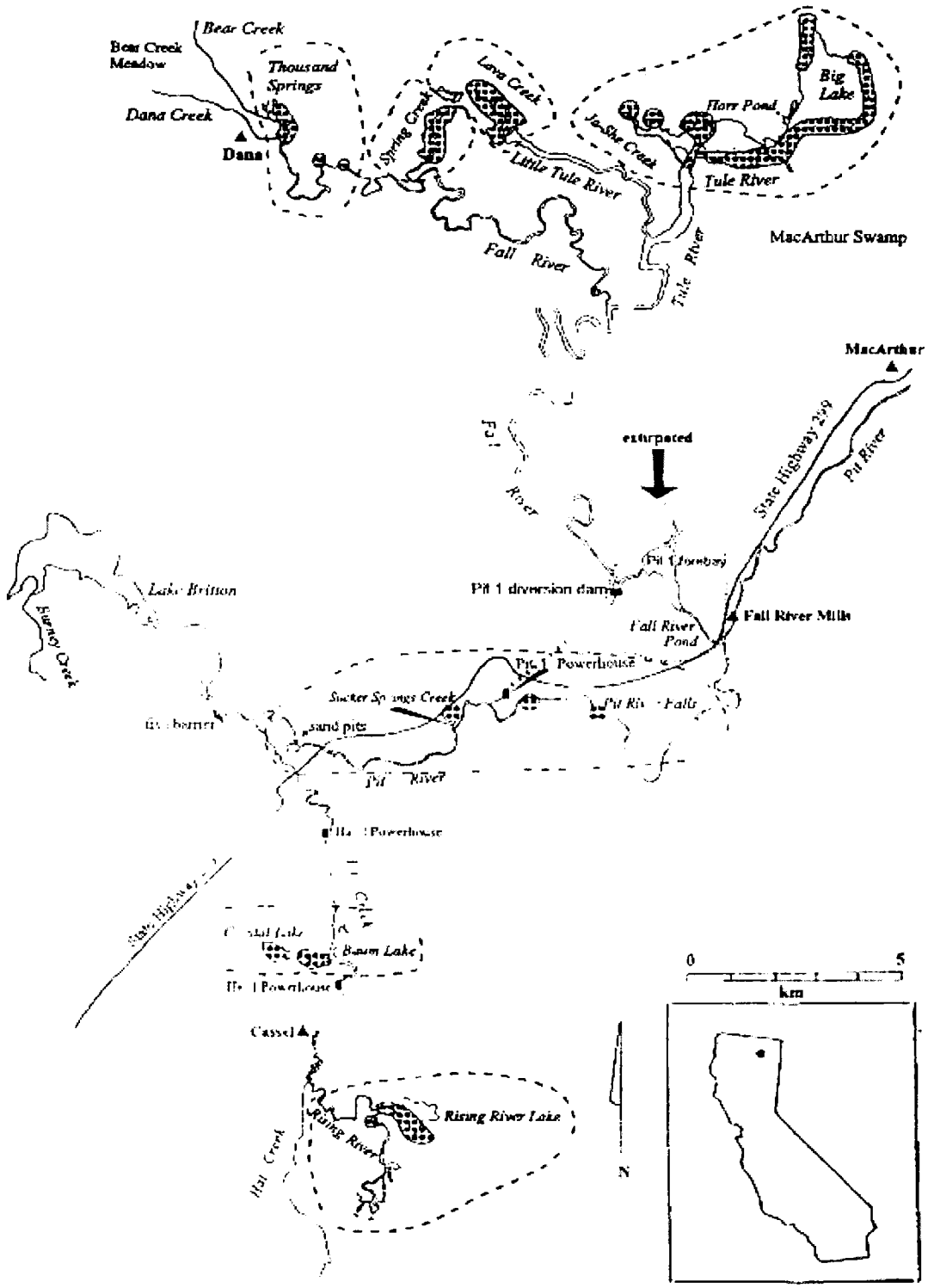

Figure 2. Eight geographically isolated regions created by hydrologic development as well as other disturbances. Image from Service 1998.

Shasta crayfish were probably never continuously distributed throughout their range although, its distribution within that range is more fragmented than it was historically.

The population of Shasta crayfish at the time of listing in 1988, were separated into eight geographically isolated subpopulations due to habitat loss and habitat alteration caused by the development of hydropower generation facilities and fish barriers as well as natural occurrences such as mudflows and sedimentation (Figure 2). Currently, the distribution of Shasta crayfish has become more fragmented than at the time of listing (Table 1). The expansion of nonnative crayfish into the Shasta crayfish range has increased, causing stretches of unsuitable habitat and created hostile barriers to Shasta crayfish movements (Light *et al.* 1995; Spring Rivers Ecological Sciences, 2004, 2005, 2006, 2007, and 2008).

Abundance

Because the survey methodology has differed between the earliest surveys in the late 1970s and the surveys conducted in the early 2000s, we can only make generalized assessments of population counts and trends. Overall, Shasta crayfish populations have declined since listing. The first systematic survey for Shasta crayfish documented crayfish occupation in 14 of 16 locations that were surveyed (Daniels 1980). The approximate population size of less than 6,000 individuals was estimated for the 14 locations. Research surveys funded by the California Department of Fish and Game (CDFG) in the early 1990s (Light *et al.* 1991) and surveys required for the Federal Energy Regulatory Commission's (FERC) relicensing of Pacific Gas and Electric Company's (PG&E) Pit 1 and Hat 1 Hydroelectric Facilities (Ellis and Hesseldenz 1993; Ellis 1994; Spring Rivers Ecological Sciences 2001, 2004, 2005, 2006, 2007), included surveying 29 sites (including all of the original sites from 1978). None of these survey efforts attempted to estimate population size. Rather these reports discuss occupied locations, numbers of Shasta crayfish and exotic crayfish per site and, Shasta crayfish densities as measurements of Shasta crayfish stability and health (Appendices 1 and 2). Some of these subpopulations appear stable, others have declined sharply. At the time of listing, Shasta crayfish occupied approximately 80 percent of the sites surveyed; this occupation rate is down to 58 percent. The sex ratio for Shasta crayfish remains essentially equal, but the age class distribution is now biased towards adults, indicating a decreased survival of smaller age class crayfish (Spring Rivers Ecological Sciences 2008).

Habitat or Ecosystem

Shasta crayfish occur in cool, clear spring-fed lakes, rivers and steams. They tend to occur at or near spring inflow sources, where the waters have little fluctuation in temperature. They are dependent upon a clean, firm, sand or gravel substrate with large (> 7.5 cm in diameter) rocks for cover (Eng and Daniels 1982). There has been little change in this habitat or ecosystem since listing. The main impacts to Shasta crayfish habitat (development of reservoirs for hydroelectric facilities) were in place long before the listing. While the structures and facilities for the hydroelectric operations have not changed, the flow regimes were modified with the 2003 license renewal for Pit 1 (FERC Project Number 2687) and Hat Creek (FERC Project Number 2661) (PG&E 2003a, 2003b). In 2007, two crayfish barriers were constructed, one in upper Fall River and the other at the downstream end of Spring Creek. These barriers should protect these upstream habitats from new invasions of non-native crayfish, while efforts to remove the remaining non-native crayfish in these areas continue (Spring Rivers Ecological Sciences 2007).

Table 1 Eight Geographically Isolated Shasta crayfish populations and their associated subpopulations in estimated number of individuals, organized from north to south, and east to west. Numbers rounded to nearest 10 when below 100, to nearest 100 when larger than 100 (Ellis and Cook 2008).

Population	Ownership	Exotic Crayfish	Shasta Crayfish
subpopulation		Status	Status
Upper Fall River			
Thousand Springs – above barrier	Private	>30	Stable (>200)
Thousand Springs—below barrier	Private	>30	Declining (0?)
Rainbow Spring	Private	>100	Stable (<10)
Fletcher's Bend	Private	>400	Declining (0?)
Lennihan's Footbridge	Private	>100	Declining (0?)
Spring Creek			
Upper Coves	Private	>40	Stable ? (>100)
Lower Coves	Private	>40	Stable ? (>10)
Lava Creek	Private	>100	Declining (<20)
Upper Tule River (Ja She Creek)			
Ja She Creek headwaters	State Park	>1300	Stable ? (>50)
Crystal Springs Cove, Inlet	State Park	>1700	Declining (<10)
Tule Coves	State Park	>50	Declining (<10)
Upper Tule River (Upper Big Lake)			
Big Lake Springs	Private	>100	Declining (<50)
North Big Lake	Private	>300	Declining (<10)
Northeast Big Lake	Private	<5	Declining (1)
Northwest Big Lake	Private	<5	Declining (1)
Upper Tule River (Levee System)			
South shore Big Lake	Private	>60	Declining (<10)
Northeast upper Tule River	Private	>5	Declining (0?)
South shore upper Tule River	Private	>60	Stable (<20)
East shore upper Tule River	Private	1	0
Horr Pond Levees	Private	>40	0
Fall River, Fall River Mills			
Fall River Pond	Private	>200	0
Pit River			
Pit River Falls	Private	>50	Declining (0?)
Pit River – Canyon Springs	Private	>50	Declining (0?)
Pit River sand pits	Private	>50	Declining (0?)
Sucker Springs	Private	>600	Declining (<10)
Hat Creek, Cassel			
Southwest Crystal Lake	Private	>100	Stable? (>100)
Crystal Lake, Middle Cove	Private	>100	Declining (0?)
Crystal Lake Outflow	Private	>400	Declining (<10)
Baum Lake at Crystal Lake Inflow	Private	>100	Declining (0?)
Rising River (no recent surveys)			
Midstream	Private	Unknown	<10 in 1995
Footbridge	Private	Unknown	<10 in 1995
Southern	Private	Unknown	<10 in 1995
Outflow	Private	Unknown	<30 in 1995

Genetics

The first genetic study on Shasta crayfish was initiated in 2004. Preliminary findings indicate that there is a fair amount of variation among the subpopulations. Three different genetic clusters were identified: Crystal Lake, the Big Lake group, which includes Big Lake Springs, JeShe, Lava, and Spring Creeks, and Thousand Springs (Petersen and May 2008 Genotyping of signal crayfish indicate no genetic evidence of hybridization between the species and there is insufficient information to predict trends in genetic variability (Spring Rivers Ecological Sciences 2006, 2007, and 2008; Petersen and May 2008). Management recommendations include maintaining collections of all three major genetic clusters and to avoid translocations between locations (Spring Rivers Ecological Sciences 2008; Petersen and May 2008).

Species-specific Research and/or Grant-supported Activities

The CDFG, through a section 6 grant, initiated a water temperature study to assess growth rates of Shasta crayfish and signal crayfish in two different water temperatures. Attempts to implement the study have been initiated and will continue to 2011 The results of this study should help inform the Shasta Crayfish Recovery Team on the best options for maintaining or creating refugia for Shasta crayfish from Signal crayfish.

The CDFG, through a section 6 grant, has also completed a genetic study of Shasta crayfish through the University of California at Davis. The study was completed in May 2008, although additional sampling is necessary for the Rising River and could be conducted by the lab (Peterson and May 2008).

Pacific Gas and Electric Company has funded extensive applied research in developing crayfish barriers (Spring Rivers Ecological Sciences 2008). This study tested different designs of barriers to ascertain their effectiveness in preventing crayfish movement as well as determining how the barrier design would affect water flow and stream geomorphology. The results of this research allowed a crayfish barrier to be installed in the Thousand Springs area.

A multi-year project was implemented in 2001 and completed in 2003 on Sucker Springs Creek to improve habitat by eliminating non-native crayfish from the stream. In 2006, an additional grant continued the non-native crayfish eradication effort, implemented measures to restore the geomorphic features of the stream, and eliminate non-native crayfish refugia (Spring Rivers Ecological Sciences 2008).

Five-Factor Analysis

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act.

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

At the time of listing we identified modification of habitat by water diversion and impoundment projects, hydroelectric projects livestock grazing, water use for residential development and associated pollution (Service 1988). Shasta crayfish are extremely restricted to lava rock cobble

areas, which they use for protective cover. Prior to listing, numerous hydroelectric facilities and water impoundments had been constructed along the Pit Creek and Hat Creek drainages. These installations adversely affect Shasta crayfish by blocking access and egress to refugia habitat, modifying habitat via increase siltation, and by isolating and separating Shasta crayfish populations (Service 1988). While there has been no major change in the hydroelectric structures or facilities, with the 2003 FERC relicensing of Pit 1 and Hat Creek, the water flows have changed. The flow changes include (1) an increase in base flows of 150 cubic feet per second (cfs) in summer; and (2) at least 75 cfs in winter. Additionally, PG&E is required to have several flushing flow releases each year to manage vegetation. At the time of relicensing, PG&E had expressed concern that the combination of these two changes in water management would likely lead to a water temperature increase where Shasta crayfish reside. Data collected over the last several years does indicate that the flow regimes required by the license have in fact increased water temperature due to the warmed water from the forebays overwhelming the cold water coming up from the natural springs in the area. An increase in water temperature would favor the exotic signal crayfish. Therefore, the current water management in the Hat Creek and Pit River appears to have a larger negative effect on Shasta crayfish as compared to water management at the time of listing (PG&E 2009). This threat is current and on-going and may be a significant threat to the continued viability of Shasta crayfish and water flow management regimes should be more closely monitored and reassessed. Other habitat modification factors identified in the final listing (livestock grazing, water use for residential development, increased pollution) that could impact Shasta crayfish habitat do not appear to be significant factors at this time. Of the 33 known occurrences, three are on California State Park lands, and the remaining 30 are on privately owned lands.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

At the time of listing, incidental capture of Shasta crayfish for human consumption was predicted to be a minor factor (Service 1988). Since listing, there is no data to support that overutilization is a threat. Overutilization for commercial, recreational, scientific, or educational purposes does not appear to be a threat to the Shasta crayfish at this time.

FACTOR C: Disease or Predation

Neither disease nor predation was identified as a threat at the time of listing. Predation by exotic species of fish and crayfish was identified as a threat in the Recovery Plan. The introduction of exotic species of fish and crayfish, which are potential predators, competitors, and sources of new diseases and pathogens, is a significant threat to the continued existence of the Shasta crayfish. Signal crayfish can both prey on Shasta crayfish and compete with Shasta crayfish. Competition from signal crayfish is discussed further under Factor E.

Many species of nonnative gamefish were intentionally introduced into the midsections of the Pit River drainage to provide sport fishing opportunities. Some of these introductions were without the sanction of California Department of Fish and Game and other agencies. Brown trout (*Salmo trutta*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus Dolomieui*), black crappie (*Pomoxis nigromaculatus*), green sunfish (*Lepomis cyanellus*), black bullhead

(*Ameiurus melas*), brown bullhead (*Ameiurus nebulosus*), and channel catfish (*Ictalurus punctatus*) have all been introduced within the range of the Shasta crayfish and are all known to prey on crayfish (Crocker and Barr 1968; Taub 1972; Rickett 1974). Common carp (*Cyprinus carpio*), which have also been introduced in the area, eat invertebrates living on river and lake bottoms. In particular, largemouth and smallmouth bass and green sunfish are known to be voracious predators on crayfish.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

At the time of listing, regulatory mechanisms thought to have some potential to protect Shasta crayfish included: (1) listing under the California Endangered Species Act (CESA); and (2) State regulations that prohibit the take, possession, or uses for bait any crayfish species at any time of year within the range of Shasta crayfish. As noted in the listing rule (Service 1988) due to the range of the species being large and remote, these regulations are difficult to enforce. This analysis remains valid.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

At the time of listing, the spread of two exotic crayfish species into the range of Shasta crayfish was identified as a significant threat. Currently, competition from exotic crayfish species remains a significant threat. Additionally, Shasta crayfish is threatened by stochastic events and small population size.

Competition with Exotic Crayfish

At the time of listing, the spread of two exotic crayfish, signal crayfish (*Pacifactacus leniusculus*) and fantail crayfish (*Orconectes virilis*), into the range of Shasta crayfish was identified as a significant threat. These exotic species, especially signal crayfish, are aggressive competitors that mature quickly (at 2 years old), have a higher reproductive ability (100-150 eggs per female), grow faster, and are larger (Momot 1967; Bouchard 1977; Shimizu and Goldman 1981, Eng and Daniels 1982). The mechanism by which the signal crayfish excludes the Shasta crayfish is by a combination of competition and predation. Of the 16 sites surveyed in 1978, exotic crayfish were observed at two of them. Of the 32 locations surveyed in 1990-1991, fifteen locations were occupied by exotic crayfish. During the most recent surveys (Spring Rivers Ecological Sciences 2004, 2005, 2006), 29 locations (i.e. all locations) contained exotic crayfish. The number of individual Shasta crayfish appears to be declining in most of the sub populations (Appendices 1 and 2), the density of Shasta crayfish has declined, and the number and density of exotic crayfish (specifically signal crayfish) has increased (Appendices #1 and 2). The only areas showing declines in exotic crayfish numbers are those where crayfish removal efforts, funded by PG&E as an Article in the licenses for Pit 1 and Hat 1 Hydroelectric Facilities, have been underway. As the exotic crayfish populations increase in size and distribution, Shasta crayfish populations reduce in number and become more isolated. As exotic crayfish have increased in density and range within the Pit and Fall River drainages, the intervening habitat has become more "hostile" to Shasta crayfish thus increasing the isolation between subpopulations.

Small Population Size, Stochastic Events, and Habitat Fragmentation.

Shasta crayfish is threatened by small population size. Of the 29 sites surveyed in 2004-2006, 12 no longer have Shasta crayfish, 8 have fewer than 10 individuals, and only 3 have more than 100 individuals (Table 1, Appendices #1 and 2). Small populations may be subject to inbreeding depression and genetic drift, and also to chance extinction from stochastic environmental and demographic incidents (Gilpin and Soulé 1986; Goodman 1987; Shaffer 1987). Genetic analyses conducted by Petersen and May (2008) show that in general there is a great deal of genetic variation in the remaining Shasta crayfish populations despite the demographic data showing a severe reduction in population size.

Shasta crayfish is also threatened with an increase in fragmented populations (further threat of genetic drift and isolation) (Lesica and Allendorf 1995; Holsinger 2000). Fragmented populations often exhibit poor metapopulation connectivity where the dispersal distance between populations are outside the capability of the species and thus make the species less likely to disperse to other populations sites or recolonize sites that may have been extirpated (Lesica and Allendorf 1995; Hanski and Simberloff 1997; Holsinger 2000).

Global Climate Change

Impacts to the Shasta crayfish under predicted future climate change are unclear. A trend of warming in the mountains of western North America is expected to decrease snowpack, hasten spring runoff, and reduce summer stream flows, and increased summer heat may increase the frequency and intensity of wildfires (IPCC 2007). While it appears reasonable to assume that the species may be affected, we lack sufficient certainty on knowing how and how soon climate change will affect the species, the extent of average temperature increases in California/Nevada, or potential changes to the level of threat posed by increased drought or fire. The most recent literature on climate change includes predictions of hydrological changes, higher temperatures, and expansion of drought areas, resulting in a northward and/or upward elevation shift in range for many species (IPCC 2007). We have no knowledge of more detailed climate change information specifically for this species' range.

III. RECOVERY CRITERIA

Recovery plans provide guidance to the Service, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. There are many paths to accomplishing the recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded while other criteria may not have been accomplished. In that instance, we may determine that, over all, the threats have been minimized sufficiently, and the species is robust enough, to downlist or delist the species. In other cases, new recovery approaches and/or opportunities unknown at the time the recovery plan was finalized may be more appropriate ways to achieve recovery. Likewise, new information may change the extent that criteria need to be met for recognizing recovery of the species. Overall, recovery is a dynamic process requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a

recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed (or since the most recent 5-year review) by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

Criteria for Downlisting:

1. The 20 major subpopulations within 5 Shasta crayfish populations that are currently free of non-native crayfish species are protected to ensure they remain isolated from non-native crayfish species, and these subpopulations are stable (i.e., self-sustaining and comprising representatives of all age classes).

This criterion is not current, since all subpopulations of Shasta crayfish are now invaded by exotic crayfish. Efforts have been made in the construction of two crayfish barriers. Above these barriers, exotic crayfish removal efforts have made substantial progress in reducing their populations, but these areas are not yet free of exotic crayfish. This criterion is still vital for the stabilization and ultimate protection of Shasta crayfish. This criterion addresses Factor E.

2. The Crystal Lake and Sucker Springs Creek subpopulations, which have been invaded by signal crayfish, are protected and stable due to elimination, reduction, or management of signal crayfish.

This criterion has been partially implemented. The Sucker Spring Population is one of the barrier/restoration locations. With continued effort in 2008-2010, this will likely be achieved. Crystal Lake has been completely invaded by exotic crayfish and Shasta crayfish populations have declined. It is not clear that eradication of exotic crayfish from this location is feasible. This criterion addresses Factor E.

3. Over a 5-year period, population sizes remain constant at Upper Fall River, Spring Creek, and Rising River, and population sizes increases at Lava Creek, upper Tule River, Crystal Lake, and Sucker Springs.

This criterion has been partially achieved. Upper Fall River is one of the barrier locations constructed in 2007, and this barrier project, with continued support for the next couple of years should ultimately be successful. Spring Creek appears stable, but there is concern with the recent invasion by signal crayfish. Due to landownership and funding mechanisms, Rising River has not been resurveyed since 1995; the status of this set of subpopulations is unknown. Shasta crayfish populations have not increased in the upper Tule River, instead numbers of Shasta crayfish have declined (potentially to zero) and exotic crayfish have increased in number and range. See comments above for Sucker Springs and Crystal Lake. Lava Creek – unknown. This criterion addresses Factor E.

4. Signal crayfish are eradicated in lower Lava Creek so that Shasta crayfish are free of signal crayfish throughout the entire Lava Creek subdrainage.

No effort has been made to work on this criterion. This criterion addressed Factor E and is still valid.

5. The major subpopulations in each of the seven Shasta crayfish populations are protected from disturbances related to land use practices.

Little to no effort has been made on this criterion, which addresses Factor A. While this criterion is still valid, it is clear that primary recovery efforts need to focus on the more immediate and larger magnitude effect from the increase of exotic crayfish in this ecosystem.

Criteria for Recovery

1. Non-native crayfish species, in particular signal crayfish, have been eliminated, reduced or are being managed in all Shasta crayfish subpopulations, so that they no longer threaten the continued existence of Shasta crayfish at these sites.

2. All Shasta crayfish subpopulations are stable, with population sizes that are increasing over a 5-year period.

Neither Recovery Criterion has been met. Exotic crayfish populations have increased in number and distribution, they continue to be a significant threat to Shasta crayfish. Most Shasta crayfish populations are not stable or increasing; most Shasta crayfish populations are declining.

IV SYNTHESIS

Shasta crayfish are thought to have always been restricted to the Pit River and Hat Creek drainages. Since the time of listing and the time since the recovery plan was completed, the Shasta crayfish has decreased in numbers and distribution. Exotic crayfish, the major threat to Shasta crayfish, have increased in number and distribution throughout the Shasta crayfish range. Additionally, the water flow regime in these two drainages was altered in 2003. This change in water management resulted in increased water temperature which favors the exotic signal crayfish due to its higher tolerance of water temperatures and its ability to grow and mature faster. Without the continued exotic crayfish removal efforts funded by PG&E, Shasta crayfish populations may possibly be in even worse condition. Due to the low number of individuals, loss of subpopulations, increased dispersal barriers, and increased threat from signal crayfish, Shasta crayfish are imminently threatened with extinction. Therefore, we believe that the Shasta crayfish meets the definition of endangered, and recommend no status change at this time.

recovery plan. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed (or since the most recent 5-year review) by eliminating or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

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This criterion has been partially implemented. The Sucker Spring Population is one of the barrier/restoration locations. With continued effort in 2008-2010, this will likely be achieved. Crystal Lake has been completely invaded by exotic crayfish and Shasta crayfish populations have declined. It is not clear that eradication of exotic crayfish from this location is feasible. This criterion addresses Factor E.

3. Over a 5-year period, population sizes remain constant at Upper Fall River, Spring Creek, and Rising River, and population sizes increases at Lava Creek, upper Tule River, Crystal Lake, and Sucker Springs.

This criterion has been partially achieved. Upper Fall River is one of the barrier locations constructed in 2007, and this barrier project, with continued support for the next couple of years should ultimately be successful. Spring Creek appears stable, but there is concern with the recent invasion by signal crayfish. Due to landownership and funding mechanisms, Rising River has not been resurveyed since 1995; the status of this set of subpopulations is unknown. Shasta crayfish populations have not increased in the upper Tule River, instead numbers of Shasta crayfish have declined (potentially to zero) and exotic crayfish have increased in number and range. See comments above for Sucker Springs and Crystal Lake. Lava Creek – unknown. This criterion addresses Factor E.

4. Signal crayfish are eradicated in lower Lava Creek so that Shasta crayfish are free of signal crayfish throughout the entire Lava Creek subdrainage.

V RESULTS

Recommended Listing Action:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (indicate reason for delisting according to 50 CFR 424.11):
    ____ *Extinction*
    ____ *Recovery*
    ____ *Original data for classification in error*
__X__ No Change

New Recovery Priority Number and Brief Rationale:

At this point, we do not recommend a change in Recovery Priority Number.

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

1. Continue removal of exotic crayfish, especially at Sucker Springs and Thousand Springs barrier sites, and expand removal efforts to protection at least one population in each of the 8 subpopulation areas.

2. Continue to explore options for constructing barriers to crayfish movement followed by intensive exotic crayfish eradication upstream of the barrier to create Shasta crayfish refugia that are free of exotic crayfish. Areas to consider are Rock Creek, Lava Creek and Rising River.

3. Establish a population of Shasta crayfish above the natural barrier.

4. Develop a Genetic Management Plan to help determine source populations for potential reintroductions of Shasta crayfish into Rock Creek and elsewhere.

5. Conduct Mitochondrial DNA work on existing Shasta crayfish genetic samples.

VII. REFERENCES CITED

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Appendix 1. Crayfish population characteristics (number, density, estimated population size, and percent composition) from previous and current surveys in the Hat Creek Project vicinity (Ellis and Cook 2008).

Area	1978 [a]	1990 [b]–1991 [c]	1993 [d]	2003 [e]	2004 [f]	2007 [g]
Southwest Crystal Lake	**12 Shasta** (100%) 0.12 Shasta/m^2	Signals (no scuba)	**31 Shasta** (50%) 31 signal (50%)	**135 Shasta** (56%) 0.045 Shasta/m^2 104 signal (44%) 0.035 signal/m^2	**245 Shasta** (53%) 0.081 Shasta/m^2 216 signal (47%) 0.072 signal/m^2	**129 Shasta** (43%) 0.043 Shasta/m^2 174 signal (57%) 0.058 signal/m^2
Middle Cove, Crystal Lake		**~2 Shasta** (33%) 4 signal (67%)	**5 Shasta** (33%) 10 signal (67%)	**2 Shasta** (1%) 0.001 Shasta/m^2 139 signal (99%) 0.076 signal/m^2	**2 Shasta** (1%) 0.001 Shasta/m^2 217 signal (99%) 0.118 signal/m^2	0 Shasta (0%) 0 Shasta/m^2 120 signal (100%) 0.075 signal/m^2
Crystal Lake Outflow	**658 Shasta** (100%) 6.89 Shasta/m^2 population size: 2000–3000 Shasta	**7 Shasta** (13%) population size: 369 ± 135 Shasta 45 signal (87%)		**23 Shasta** (1%) 0.001 Shasta/m^2 2458 signal (99%) 1.639 signal/m^2	**7 Shasta** (0.4%) 0.005 Shasta/m^2 1717 signal (99%) 1.145 signal/m^2	**2 Shasta** (0.4%) 0.001 Shasta/m^2 457 signal (100%) 0.305 signal/m^2
Baum Lake at Crystal Inflow	**3 Shasta** (1%) 0.09 Shasta/m^2 230 signal (99%) 3.81 signal/m^2	19 signals (100%)	**1 Shasta** (10%) 9 signal (90%)	0 Shasta (0%) 172 signal (100%) 0.398 signal/m^2	0 Shasta (0%) 283 signal (100%) 0.655 signal/m^2	0 Shasta (0%) 193 signal (100%) 0.447 signal/m^2

[a] Daniels, 12 June – 7 November 1978 (unpublished data in letter dated 7/13/95, Daniels 1978, Daniels 1980, Eng and Daniels 1982)
[b] Clarke and Light, 19, 22, 27 June & 3 July 1990 (Light 1990 unpublished notes, Light 1991, Light et al. 1991, Erman et al. 1993)
[c] Light and Myrick Summer 1991 (Table 7. Light 1991 unpublished data, Erman et al. 1993)
[d] Ellis and Cook, 6 August and 21 & 27 October 1993 (Ellis 1994)
[e] PG&E Shasta crayfish monitoring September 2003 – February 2004 (Spring Rivers 2004)
[f] PG&E Shasta crayfish monitoring November 2004 – February 2005 (Spring Rivers 2005)
[g] PG&E Shasta crayfish monitoring January– April 2007 (Spring Rivers 2008)

Appendix 2. Crayfish population characteristics (number, density, estimated population size, and percent composition) from previous and current surveys in the Pit 1 Project vicinity (Ellis and Cook 2008).

	Region and Location	1978 [a]	1990, 1991, 1992 [b]	2001 [c]	2004–2006 [d]
Upper Fall River	Thousand Springs – Fish Trap Cove	**20 Shasta** 0.75 Shasta/m^2	**21–230 Shasta**		**159 Shasta (90%)** Shasta/m^2 17 signal (10%) signal/m^2
	Thousand Springs – below the cove	**5 Shasta** 0.23 Shasta/m^2	**11–24 Shasta**		**45 Shasta (3%)** Shasta/m^2 1484 signal (97%) signal/m^2
	Fletcher's Bend		**4–11 Shasta** 0 Shasta (1995) 0–6 signal		427 signal (100%) 1.617 signal/m^2
	Lennihan's Footbridge		**11–13 Shasta** 0–6 signal		99 signal (100%) 0.454 signal/m^2
Spring Creek	Upper coves	**50 Shasta** Population size: 600–1000 0.79 Shasta/m^2	**9–466 Shasta** Population size: 4640 ± 627 0.83 Shasta/m^2		**273 Shasta (78%)** Shasta/m^2 77 signal (12%) signal/m^2
	Lower coves	**8 Shasta** Population size: 10–50 0.50 Shasta/m^2	**17 Shasta**		**27 Shasta** (30%) Shasta/m^2 62 signal (70%) signal/m^2
Ja She Creek	Ja She Creek headwaters	0 Shasta (at bridge)	**33 Shasta** 1 signal (at bridge)	**62 Shasta** 364 signal	**54 Shasta** (4%) 0.006 Shasta/m^2 1386 signal (96%) 0.155 signal/m^2
	Crystal Springs, Cove, Inlet	1 Shasta molt 0.04 Shasta/m^2	**11 Shasta**	**17 Shasta** 315 signal	**4 Shasta** (~0%) 0.001 Shasta/m^2 1788 signal (~100%) 0.477 signal/m^2
	Tule Coves		**16 Shasta** 8 signal	**13 Shasta** 39 signal	**8 Shasta** (13%) 0.036 Shasta/m^2 52 signal (87%) 0.237 signal/m^2

Table 2 (continued)

	Region and Location	1978 [a]	1990, 1991, 1992 [b]	2001 [c]	2004–2006 [d]
Upper Big Lake	Big Lake Springs	**12 Shasta** 1.00 Shasta/m^2	**39 Shasta**	**61 Shasta**	**36 Shasta** (92%) 0.203 Shasta/m^2 3 signal (8%) 0.017 signal/m^2
	North Big Lake		**32 Shasta**	**49 Shasta** 10 signal	**8 Shasta** (2%) 0.006 Shasta/m^2 355 signal (98%) 0.268 signal/m^2
	Northeast Big Lake	**10 Shasta** 1.11 Shasta/m^2	**5 Shasta**	6 signal	**1 Shasta** (25%) 0.004 Shasta/m^2 3 signal (75%) 0.011 signal/m^2
	Northwest Big Lake		**7 Shasta**	**3 Shasta** 12 signal	**1 Shasta** (33%) 0.091 Shasta/m^2 2 signal (67%) 0.182 signal/m^2
Tule River Levee System	South shore Big Lake	**30 Shasta** 3.56 Shasta/m^2	**0–9 Shasta**		**9 Shasta** (39%) 0.007 Shasta/m^2 3 signal (13%) 0.002 signal/m^2 11 fantail (48%) 0.009 fantail/m^2
	Northeast upper Tule River	**30 Shasta** 1.20 Shasta/m^2	**5 Shasta** 1 signal	5 signal 5 fantail	4 fantail (100%)
	South shore upper Tule River		**0–3 Shasta** 0–7 signal Shasta molts		18 signal (24%) 0.857 signal/m^2 58 fantail (76%) 2.762 fantail/m^2
	East shore upper Tule River		11 signal		1 signal (100%) No habitat identified
	Horr Pond levees		**7 Shasta**	26 signal 5 fantail	5 signal (19%) 0.067 signal/m^2 29 fantail (81%) 0.387 fantail/m^2
Fall River Pond	Fall River Pond	**1 Shasta** 0.15 Shasta/m^2	0–many signal 0–most fantail		8 signal (3%) 0.002 signal/m^2 229 fantail (97%) 0.046 fantail/m^2

Table 2 (continued)

	Region and Location	1978 [a]	1990, 1991, 1992 [b]	2001 [c]	2004–2006 [d]
Pit 1 - Big Eddy to PH	Pit River Falls		**4 Shasta** (1995) many fantail		**14 Shasta** (40%) 0.019 Shasta/m^2 9 signal (26%) 0.012 signal/m^2 12 fantail (34%) 0.016 fantail/m^2
	Pit River Canyon spring	1 dead Shasta	1 dead Shasta signal present 0 fantail		0 Shasta 91 signal 1.213 signal/m^2
Pit 1 - bel w PH	Pit River sand pits	**8 Shasta** 0.44 Shasta/m^2 271 fantail 3.11 fantail/m^2	abundant signal 0 fantail		many signal 1 fantail

[a] Daniels, June – October 1978 (unpublished data in letter dated 7/13/95, Daniels 1978, Daniels 1980, Eng and Daniels 1982)

[b] Light 1990 unpublished notes, Hesseldenz and Ellis 1991, Light et al. 1991, Erman et al. 1993, Ellis 1996

[c] Ahjumawi Lava Springs State Park Survey (Spring Rivers 2001)

[d] PG&E Shasta crayfish monitoring March 2004 – February 2007 (Spring Rivers 2007)

U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW

Shasta Crayfish (*Pacifastacus fortis)*

Current Classification: endangered

Recommendation Resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

Review Conducted By: Amy L. Fesnock and Arnold Roessler SFWO

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve Susan C Moore Date 8/19/09