Big Sandy crayfish (*Cambarus callainus*) 5-Year Review: Summary and Evaluation

Photo by: Dr. Zachary J. Loughman

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U.S. Fish and Wildlife Service
West Virginia Field Office
Davis, West Virginia

5-YEAR REVIEW
Big Sandy crayfish
(*Cambarus callainus*)

1.0 GENERAL INFORMATION

1.1 Reviewers

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1.2 Methodology used to complete the review:

This 5-year review was conducted by the lead species biologist for the Big Sandy crayfish (*Cambarus callainus*) in coordination with other U.S. Fish and Wildlife Service (Service) staff. West Virginia Division of Natural Resources (WVDNR) endangered species expert, Alexander Silvis, contributed additional information on species biology, distribution, and factors influencing the viability of the species. Virginia Department of Wildlife Resources, Aquatic Resources Biologist, Brian Watson contributed information on the distribution of the species in Virginia. Dr. Zachary Loughman, the lead academic expert on the species, provided consultation through personal communications as needed throughout the development of this 5-year review. The goal of the document is to summarize and evaluate new information and recommend whether the listing status of the species should be changed.

New data and information regarding the species' population status and habitat used in this report included peer-reviewed literature, information, and occurrence data from the WVDNR, VDWR, researchers, unpublished reports, and personal communications. The administrative record, including all pertinent literature and documents used for this review, is on file at the West Virginia Field Office.

1.3 Background:

1.3.1 Federal Register (FR) notice announcing initiation of this review:

85 FR 64527-64529

1.3.2 Listing History

FR notice: 81 FR 20449-20481
Date listed: April 7, 2016
Entity listed: Species; Entire Range
Classification: Threatened

1.3.3 Associated Rulemakings:

A final critical habitat rule for the species was published on March 15, 2022, and became effective on April 14, 2022 (87 FR 14662-14719). Designated critical habitat consists of 582 stream kilometers (skm; 362 stream miles [smi]) in four units, consisting of nineteen subunits in Kentucky (KY), Virginia (VA), and West Virginia (WV; 87 FR 14675-14676). Critical habitat is referred to as "occupied" or "unoccupied" based on its status at the time of species listing. All 582 skm were considered occupied at the time of the species' listing.

1.3.4 Review History

This review constitutes the first formal status review of the Big Sandy crayfish since the time of the species' listing in 2016.

1.3.5 Species Recovery Priority Number at Start of 5-Year Review

The Big Sandy crayfish was assigned a recovery priority number of 11C (U.S. Fish and Wildlife Service (Service 2018). The ranking scale indicates the listed entity is a species that faces a moderate degree of threat and has a low recovery potential, which may be in conflict with construction, other development, or other economic activity (denoted by the "C"; 48 FR 43098-43105, 48 FR 51935).

1.3.6 Recovery Plan or Outline

A recovery plan for the Big Sandy crayfish has yet to be completed, but the Recovery Outline for the Guyandotte River Crayfish and Big Sandy Crayfish (Service 2018) established the Service's recovery vision for the species. Although subject to change, the recovery outline provides the following long-range targets for conservation and recovery of the species: (1) multiple viable populations that are well distributed throughout the species' historical range and in habitats that are managed and protected sufficiently to conserve the species, and (2) threats to the species, primarily modification and degradation of river and stream habitat from localized and watershed

impacts, are sufficiently abated (Service 2018). The strategy for meeting these targets includes providing sufficient representation, resiliency, and redundancy to ensure the species' survival for the foreseeable future. The Service will further define what constitutes a viable population as recovery planning progresses. In general, populations should be self-sustaining, have stable or increasing numbers, demonstrate successful reproduction, and be sufficiently large and connected to other populations to withstand foreseeable threats. The Service will work with partners to prepare a recovery plan for this species and will refine these objectives and develop criteria that provide specific, measurable standards for recovery.

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

____Yes

__X_No

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

____Yes

__X_No

2.3 Updated Information and Current Species Status

The historical range of the Big Sandy crayfish was limited to the upper Big Sandy River basin in eastern Kentucky, southwestern Virginia, and southern West Virginia (figure 1). Currently, the Big Sandy crayfish is known from 21 stream systems in 3 8-digit hydrological unit code (HUC) watersheds: Tug Fork, upper Levisa Fork, and lower Levisa Fork (81 FR 20449- 20481). Since 2016, surveys have expanded our knowledge of Big Sandy crayfish presence in streams where the species was known to exist. Additionally, the species has been recorded in approximately 18.0 skm (11.2 smi) of the upper Levisa Fork, downstream of its confluence with Dismal Creek. The occurrence records in the upper Levisa Fork are new and are not within designated critical habitat for the species.

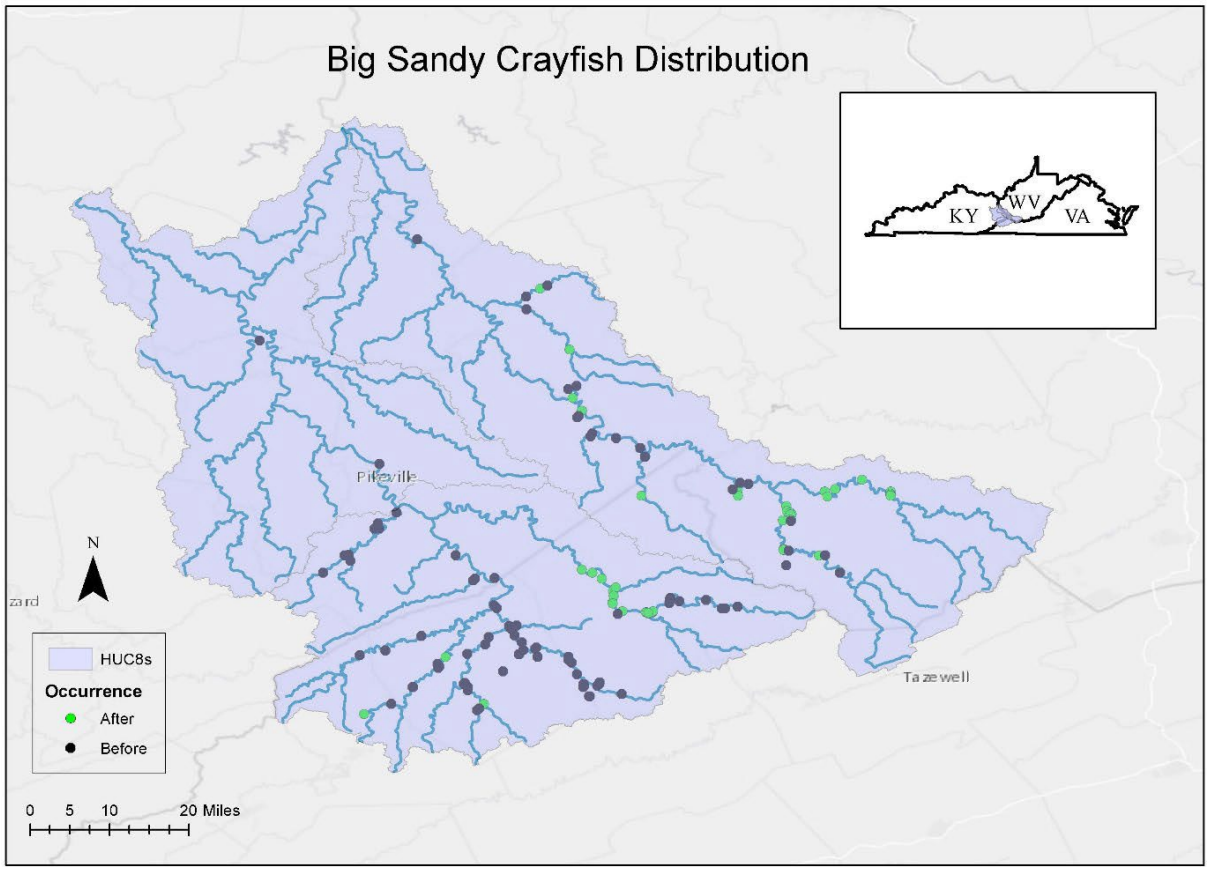

Figure 1. Current distribution of the Big Sandy crayfish in the upper Big Sandy River drainage of Kentucky, Virginia, and West Virginia. Black circles represent occurrence records obtained prior to listing (prior to 2016), while green circles represent occurrence records obtained after listing (after 2016).

2.3.1 Biology and Habitat

New information on the biology and life history of the Big Sandy crayfish has contributed to a greater understanding of the species' life history and ecology (Vopal and Loughman 2021; WSSNFH 2023). The new information is summarized below.

2.3.1.1 New information on the species' biology and life history:

Big Sandy crayfish mating occurs in spring and early summer (Vopal and Loughman 2021). Vopal and Loughman (2021) reported finding young of the year in both late fall and spring, suggesting a prolonged spawning period and an extended egg release period for the species (figure 2). Large, stream-dwelling, female *Cambarus* crayfish that are reproductively active select slab boulders closer to stream banks in late summer and fall when egg extrusion occurs (Sadecky 2020). This habitat selection likely allows crayfish to avoid faster velocity flows, which could increase egg loss. Eggs develop and hatch on the underside of the female crayfish's abdomen and stay attached until they have developed enough to become free living. Once juveniles have developed, the female *Cambarus* crayfish then selects slab boulders near the head

of a riffle to help facilitate dispersal of young (Sadecky 2020). Juveniles tend to select habitat in shallows along the stream margin after dispersing from the female (Sadecky 2020).

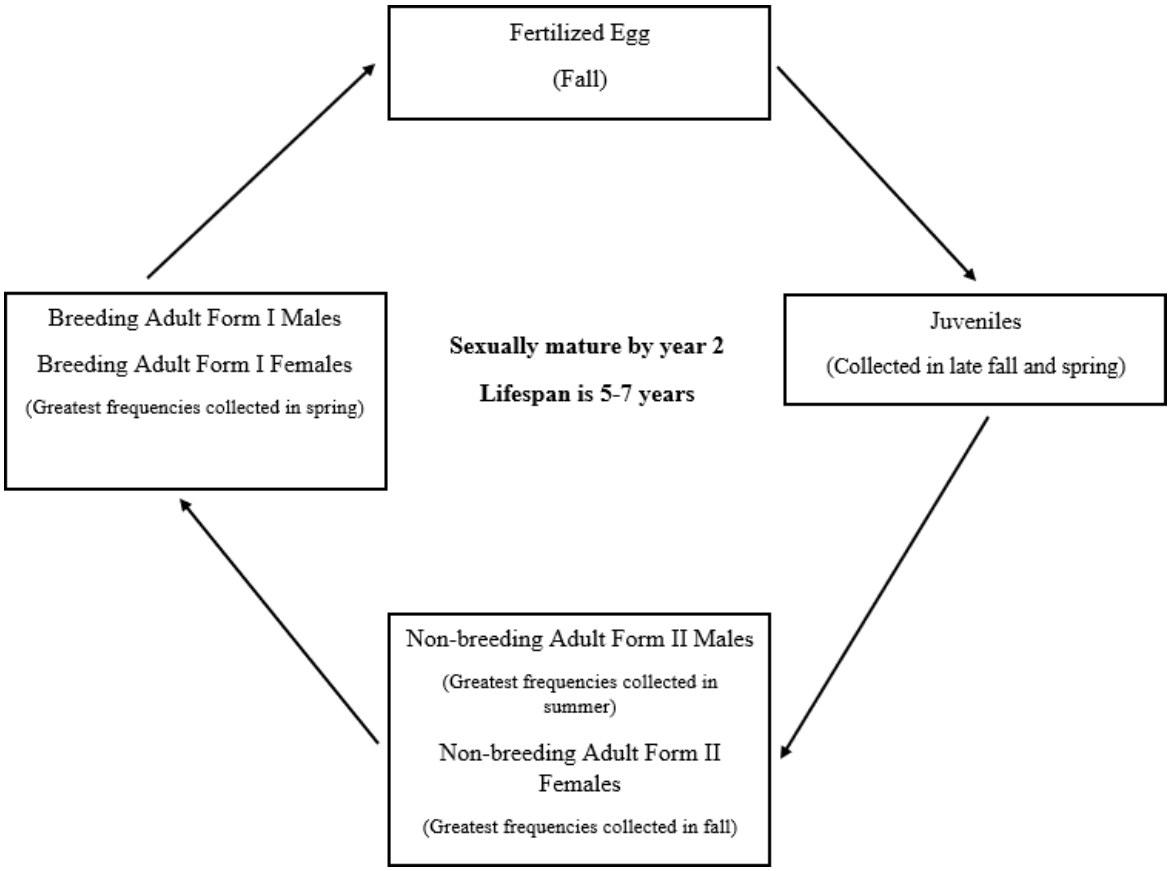

Figure 2: Generalized Big Sandy crayfish life cycle.

Reproductively inactive female and male Guyandotte River crayfish primarily selected slab boulders at the head of riffles, as well as runs that are closely associated with riffles (Sadecky 2020). Because the Big Sandy and Guyandotte River crayfishes are closely related, exhibit characteristics of other large, tertiary burrowing crayfish species, and occupy streams with similar geological morphologies, it is likely that the Big Sandy crayfish selects similar habitats and has a similar life history (Loughman 2015; Loughman *et al*. 2017; Sadecky 2020; Vopal and Loughman 2021).

In 2022, White Sulphur Springs National Fish Hatchery (WSSNFH) developed a plan to raise Big Sandy crayfish juveniles and learn more about holding listed *Cambarus* crayfish in captivity. This process of raising juveniles is called "head starting" and is a conservation technique for threatened and endangered species in which juveniles are raised in a laboratory setting and then released into the wild to help augment existing populations. Additional goals for head starting includes providing a greater proportion of juvenile crayfish to reach independence within the lab, without predation or loss to other natural causes (WSSNFH 2023).

In September 2022, 10 reproductively active Big Sandy crayfish females were collected from the wild and held in captivity so that any fertilized females could drop their eggs and begin rearing

juveniles. Unfortunately, the collection of these wild individuals occurred shortly after the timeframe that most reproductively active female Big Sandy crayfish had already laid eggs and released juveniles into the population. The animals that were collected from the wild did not produce eggs in the fall of 2022, and 9 of 10 crayfish were released back into the population from which they came the following spring. The tenth individual was large and presumably old and died during what is believed to be its "terminal molt." The "terminal molt" is defined as the final molt in a crayfish's life and individuals often die due to the stressful nature of the event (Loughman, West Liberty University, West Liberty, West Virginia, pers. comm. 2023).

Due to the lack of success in the 2022 propagation effort, changes were made to the head starting activity plan to increase production of juvenile crayfish in 2023. The changes to the activity plan allowed the WSSNFH to collect eggs and juvenile Big Sandy crayfish from female crayfish in the wild to reduce the stress on reproductively active female crayfish in captivity. The additional stress on females that results from capture, handling, and holding the species in captivity prior to and during the egg extrusion period may have affected the viability of eggs that are extruded in captivity.

Collection of reproductively active female Big Sandy crayfish occurred in July and August 2023 to assure the window for reproduction was not missed. In July, four reproductively active female Big Sandy crayfish were collected and transported to WSSNFH. Two of the four individuals produced eggs in captivity, although it was immediately apparent that the eggs were not viable. Although the eggs were not viable, the captive crayfish were healthy and there was no mortality of captive adult Big Sandy crayfish. These Big Sandy crayfish were released back into the stream from which they were captured. In August, biologists from WSSNFH and West Liberty University collected eggs and not yet free-living juvenile crayfish from wild Big Sandy crayfish and transported the eggs and juveniles back to WSSNFH to begin head starting efforts. A total of 84 eggs were collected from 3 females, and 174 hatched juveniles were collected from an additional 3 females (258 eggs and juveniles collected). Average survival of eggs to hatching was 81 percent (68 individuals) and survival of hatched eggs and collected juveniles to the final instar was 81 percent (196 individuals). Of 196 final juvenile instars, 40 percent survived to adulthood (77 individuals; Phipps pers. comm. 2024). It is believed that the survival rate from the juvenile to adult life stage in the wild is much lower than 40 percent (Loughman, West Liberty University, West Liberty, West Virginia, pers. comm. 2023).

Though much remains to be learned about the species' life history, this new information will help target habitat protection, restoration, and captive propagation efforts.

2.3.1.2 Abundance, population trends, demographic features and/or demographic trends:

State and Federal partners and university researchers completed surveys each year since the Big Sandy crayfish was listed (WLU 2019; WVDNR 2021; VDWR 2023); however, annual surveys have not been completed for all populations, and sampling efforts have varied in intensity depending on survey objectives (i.e., presence/absence survey, life history sampling). These differences have made it difficult to use the resulting information to calculate population abundances and trends.

In 2018, Vopal and Loughman (2021) surveyed the Dry Fork of the Tug Fork River in West Virginia, and the Russell Fork and Indian Creek in the upper Levisa Fork drainage in Virginia. Sampling occurred once per month for 1 year in both watersheds. During periods of high flow,

Indian Creek was surveyed instead of the Russell Fork due to safety concerns (Vopal and Loughman 2021). While not producing direct estimates of population abundance, the study allowed for comparison of abundances between streams in the two drainages. Additionally, the study provided Big Sandy crayfish demographic information for both populations.

A comparison of Dry Fork and Russell Fork data revealed that Big Sandy crayfish abundance was higher in the Russell Fork (Vopal and Loughman 2021). Vopal and Loughman (2021) reported five Big Sandy crayfish size classes within the Dry Fork, Russell Fork, and Indian Creek populations. Dry Fork, Russell Fork, and Indian Creek contained individuals ranging from juveniles to geriatric adults, indicating that natural reproduction and recruitment are occurring in both populations.

Since 2016, presence/absence surveys in the Tug Fork, upper Levisa Fork, and lower Levisa Fork drainages have provided evidence of the species' persistence in these systems; however, these surveys have not provided estimates of abundances or demographics information (WLU 2019; WLU 2021). Additional work is needed to better understand population abundance and demographics in most Big Sandy crayfish populations.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding):

Our assessment at the time of listing remains valid and suggests the isolated Big Sandy crayfish subpopulations are vulnerable to loss of genetic diversity due to genetic drift, potentially increasing their susceptibility to inbreeding depression and reducing the fitness of individuals (81 FR 20449-20481).

In August 2021, rangewide genetic sampling efforts occurred (Loughman and Garrison 2024). Results indicate high levels of homozygosity amongst single nucleotide polymorphism loci (a change in the DNA sequence where one nucleotide is different from the reference sequence) and the species displays moderate to high levels of inbreeding across its range.

The Big Sandy crayfish is represented by three populations across its range. The three populations for the Big Sandy crayfish are the Tug Fork, Russell Fork, and Shelby Creek and Dismal Creek. Genomic data suggest a moderate geographic barrier between Russell Fork mainstem (and tributaries) and the rest of the distribution somewhere upstream of the Russell Fork and Levisa Fork confluence. Shared ancestry from both the Tug Fork and Russell Fork can be found in Shelby Creek and Dismal Creek, indicating that gene flow between the Tug Fork and Upper Levisa Fork must have been extensive throughout the unsampled Lower Levisa in Kentucky historically (Loughman and Garrison 2024). Further clarification of methods and additional analyses in progress as of January 2025 may provide further insights useful for recovery planning and implementation (Garrison, West Liberty University, West Liberty, West Virginia, pers. comm. 2025).

2.3.1.4 Taxonomic classification or changes in nomenclature:

There have been no changes in nomenclature or taxonomic classification of the Big Sandy crayfish since its listing as a full species in 2016.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g., increasingly fragmented, increased numbers of corridors, etc.), or historical range (e.g., corrections to the historical range, change in distribution of the species within its historical range, etc.):

The historical range of the Big Sandy crayfish is limited to the upper Big Sandy River basin in eastern Kentucky, southwestern Virginia, and southern West Virginia (figure 1). Currently, the Big Sandy crayfish occupies 21 stream systems in 3 drainages within the upper Big Sandy River basin; Tug Fork, upper Levisa Fork, and lower Levisa Fork (81 FR 20449- 20481).

Approximately 582 skm (362 smi) were designated as critical habitat for the Big Sandy crayfish in 2022. These streams or stream segments were considered occupied at the time of listing and contain all known extant populations (87 FR 14675-14676).

Since 2016, survey data have helped us understand the distribution of Big Sandy crayfish throughout its range. The most notable occurrence data collected provided evidence that the species inhabits more of the upper Levisa Fork than previously believed. Prior to listing, the Big Sandy crayfish was known from one record in the upper Levisa Fork, near its confluence with Dismal Creek (Jones et al 2010). Surveys conducted in 2022 documented Big Sandy crayfish presence nearly 18.0 skm (11.2 smi) downstream of the 2002 capture location (VDWR 2023). These data indicate that the Big Sandy crayfish can recolonize areas with suitable habitat. It is also possible that the new detections are a product of increased sampling efforts since the species was listed in 2016.

2.3.1.6 Habitat or ecosystem conditions:

The Qualitative Habitat Evaluation Index (QHEI) is used to assess stream physical habitat quality (OEPA 2006; Rankin, 1995; Burskey & Simon, 2010; Gazendam et al., 2011). QHEI values can range from “0” to “100,” with “0” reflecting the worst and “100” the best (reference) stream conditions. A prior study by Loughman (2015) demonstrated that Big Sandy crayfish presence was associated with QHEI scores greater than 70.

From 2018 to 2019, Vopal and Loughman (2021) surveyed portions of the Dry Fork, Russell Fork, and Indian Creek. Although QHEI scores were not reported in the literature, Vopal and Loughman (2021) provided a description of habitat quality. Habitat quality in the Russell Fork and Indian Creek reflected suitable habitat conditions described in the 2016 Federal listing rule (81 FR 20449-20481), specifically low-silt, fast-flowing streams with an abundance of unembedded slab boulders. Compared to the Russell Fork, habitat and ecosystem conditions in Dry Fork were not as suitable for the Big Sandy crayfish. High levels of substrate embeddedness, thick “mud-like” sediment deposits on available slab boulders and large cobble, and frequent trash and debris piles were observed each month of survey activities in the Dry Fork (Aulick pers. obs. 2018; Vopal and Loughman 2021).

2.3.2 Five Factor Analysis

The purpose of a 5-year review is to recommend whether a listed taxon continues to warrant protection under the ESA and, if so, whether it should be reclassified (from threatened to endangered, from endangered to threatened, or delisted). This requires that the analysis of the

threats to the species be performed while assuming that the species is not receiving the regulatory protections, funding, recognition, and other benefits of ESA listing. Summaries of ongoing applications of ESA regulatory protections may shed light on additional activities that constitute threats to the species. However, the analysis under Factor D (Inadequacy of Existing Regulatory Mechanisms) focuses on the adequacy of *existing alternative (i.e.,* non-ESA mechanisms) to address the continuing and foreseeable threats.

The final listing rule described threats to the Big Sandy crayfish including: sedimentation and siltation from development; water quality degradation; habitat changes; isolation of populations; and direct habitat disturbance (81 FR 20449-20481).

2.3.2.1 Factor A. Present or threatened destruction, modification or curtailment of its habitat or range:

The best available data indicate that the primary threats to the Big Sandy crayfish throughout its range are land-disturbing activities that increase erosion and sedimentation, which degrades the stream habitat required by the species. Identified sources of ongoing erosion and sedimentation that occur throughout the range of the species include active surface coal mining, commercial forestry, unpaved roads, gas and oil development, road construction, and stream modifications associated with channel instability. Additionally, three major flood control reservoirs have inundated approximately 89 skm (55 smi) of riverine habitat throughout the range of the Big Sandy crayfish. These reservoirs inhibit gene flow between populations and degrade aquatic habitats previously used by the species (81 FR 20449-20481).

The primary threats associated with destruction, modification, or curtailment of the Big Sandy crayfish's habitat or range are currently ongoing and are expected to continue into the future.

2.3.2.2 Factor B. Overutilization for commercial, recreational, scientific, or educational purposes:

At the time of listing there was no specific information available to suggest that overutilization for commercial, recreational, scientific, or educational purposes presented a threat to the Big Sandy crayfish (81 FR 20449-20481). This continues to be true. Currently, the primary source of utilization is for scientific purposes focused on better understanding the species and planning for its recovery. Research activities have minimal potential to harm individuals through the removal of tissues for genetic analyses or crushing of individuals by foot traffic during survey efforts. Take associated with scientific research is permitted via ESA Section 10(a)(1)(A).

2.3.2.3 Factor C. Disease or predation:

At the time of listing there was no specific information available to suggest that disease or predation presented a threat to the Big Sandy crayfish (81 FR 20449-20481). This continues to be true. There is no new relevant information regarding disease or predation.

2.3.2.4 Factor D. Inadequacy of existing regulatory mechanisms:

Because the purpose of this 5-year review is to determine whether the Big Sandy crayfish continues to warrant protection under the ESA, we focus here on the sufficiency of other (i.e., non-ESA) existing regulatory mechanisms to address the continuing and foreseeable threats discussed under factors A, B, C, and E, were the species not listed under the ESA. At the time of listing in 2016, few existing Federal or State regulatory mechanisms specifically protected Big Sandy crayfish or the aquatic habitats where it occurs. However, its habitat is afforded some protection from water quality and habitat degradation under the Federal Clean Water Act (CWA)(33 U.S.C. 1251 et seq.) and the Surface Mining Control and Reclamation Act of 1977 (SMCRA)(30 U.S.C. 1201 et seq.). State laws, such as the West Virginia Water Pollution Control Act (WVSC sec. 22–11); Logging and Sediment Control Act (WVSC sec.19–1B); Kentucky regulations for water quality, coal mining, forest conservation, and natural gas development (401 KAR, 402 KAR, 405 KAR, 805 KAR); and the Virginia State Water Control Law (Va. Code sec. 62.1–44.2 *et seq.*) also provide limited protections for the habitat in which the species occurs (81 FR 20473). Streams occupied with Big Sandy crayfish in Kentucky have additional water quality protections because they are designated as outstanding state resource waters (401 KAR 10:031, Section 8). Additionally, the Big Sandy crayfish is listed as endangered by the State of Virginia (Va. Code sec. 29.1–563 to 570), which provides that species some direct protection within the Virginia portion of its range. However, while water quality has generally improved since 1977, when the CWA and SMCRA were enacted or amended, there is continuing, ongoing degradation of habitat for both species, as detailed in the listing rule (81 FR 20449- 20481). Since listing in 2016, there have been no new regulatory mechanisms to address the continuing and foreseeable threats to Big Sandy crayfish.

2.3.2.5 Factor E. Other natural or manmade factors affecting its continued existence:

Climate Change

The Intergovernmental Panel on Climate Change (IPCC) concluded that the evidence for warming of the global climate system is unequivocal (IPCC 2013). An increasingly large body of scientific research indicates climate change poses a significant threat to a variety of species and ecosystems (Thomas, *et al.* 2004; Byers and Norris 2011; IPCC 2014, Chapter 4), with freshwater ecosystems being considered especially vulnerable to the direct effects of climate change, such as altered thermal regimes and altered precipitation and flow regimes (IPCC 2014).

Temperatures in central Appalachia have increased since the beginning of the 20th century. Unprecedented warming is also projected during this century, with increases in the intensity of heat and cold wave events. Total precipitation has increased since 1900, with higher and more intense precipitation projected to occur during winter and spring. Along with more intense, prolonged precipitation events, droughts are expected to occur more frequently due to temperature caused increases in the rate of soil moisture loss during dry spells (Environmental Protection Agency (EPA) 2016a; EPA 2016b; Runkle et al. 2022a; Runkel et al. 2022b).

Climatic changes could pose a threat to the Big Sandy crayfish by increasing the frequency and magnitude of stochastic and catastrophic events. These events have the potential to directly affect habitat, as well as individual Big Sandy crayfish. An increase in the frequency and duration of droughts in the summer will affect the Big Sandy crayfish by reducing dissolved oxygen, available habitat, and food sources during the mating season (Loughman, West Liberty

University, West Liberty, West Virginia, pers. comm. 2022). Additionally, an increase in theintensity and frequency of flooding events will increase the amount of pollutants entering streams, as well as cause substrate embeddedness in these habitats (Loughman, West Liberty University, West Liberty, West Virginia, pers. comm. 2022; Silvis, West Virginia Division or Natural Resources, Elkins, West Virginia, pers. comm. 2022). An increase in pollutants has the potential to disrupt important life history events, such as molting and reproduction, and increased substrate embeddedness will reduce the amount of available habitat for the Big Sandy crayfish (Loughman, West Liberty University, West Liberty, West Virginia, pers. comm. 2022; Silvis, West Virginia Division or Natural Resources, Elkins, West Virginia, pers. comm. 2022). Prolonged droughts and an increase in high water events may ultimately reduce the recruitment of juvenile Big Sandy crayfish each year as climate change progresses.

Climatic changes also have the potential to shift important life history events to inappropriate times that may result in mortality or reduced recruitment (e.g., mistiming of reproduction) for the Big Sandy crayfish (Sadecky 2020; Loughman, West Liberty University, West Liberty, West Virginia, pers. comm. 2022). *Faxonius obscurus*, a Cambarid crayfish native to the upper Ohio River drainage, was observed releasing eggs in early March (egg extrusion generally occurs in April for this species) after a long warm spell. Shortly after the warm spell, a cold front occurred, females entered a diapause, a water mold began to form on the egg masses and the eggs eventually died, ultimately reducing juvenile recruitment rates for that year (Loughman, West Liberty University, West Liberty, West Virginia, pers. comm. 2022). Unlike the Big Sandy crayfish, most *Faxonius* produce many young and have the potential to recover populations more easily after stochastic and catastrophic events (Aulick 2020; Loughman, West Liberty University, West Liberty, West Virginia, pers. comm. 2022). The Big Sandy crayfish has a much more restricted range and has fewer young compared to *Faxonius* species, making it more susceptible to extirpation if these events occur.

Spills

Spills of pollutants and sediments into waterways have the potential to negatively impact water quality and habitats that Big Sandy crayfish rely on and likely results in reduced survival of individuals, reduced recruitment, increased vulnerability to other stressors (poor water quality can result in decreased health) and may change behaviors of individuals including limiting sheltering habitats (burying substrates). More information on the effects of water quality degradation on the Big Sandy crayfish is available in the species listing rule (81 FR 20449-20481).

Since 2016, two black water mine discharges have been documented in the range of the Big Sandy crayfish in Virginia. Blackwater is defined as a mixture of coal dust and water and consists of high concentrations of solids and minerals, which cause adverse effects to aquatic organisms by increasing the specific conductance of aquatic habitats (EPA 2000).

On May 8, 2019, a release of black water discharge occurred in Mill Branch, a tributary of Dismal Creek. Black water mine discharge was observed in Dismal Creek, 2 miles downstream of the confluence with Mill Branch (Virginia Energy 2019). On March 17, 2020, a release of black water mine discharge occurred to Long Branch; the discharge was detected over 6 miles downstream from the mine (Virginia Energy 2020).

On February 13, 2020, a 96-car train derailed near Elkhorn, Kentucky, spilling its ethanol load into the Russell Fork (Floyd pers. comm. 2022). River levels were high due to recent heavy precipitation, which may have reduced the adverse effects to the species due to dilution (Floyd pers. comm. 2022).

It is unknown if these spill events had a direct impact on the Big Sandy crayfish population in the Russell Fork, as mortality of the Big Sandy crayfish was not observed in the field. The risk of spills impacting the Big Sandy crayfish or their habitat, as described in more detail in the 2016 listing rule, is currently ongoing and expected to continue into the future.

Invasive Species

An invasive species, the virile crayfish (*Faxonius virilis*), has been observed alongside the Big Sandy crayfish in Kentucky during surveys (Floyd pers. comm. 2022a; Loughman pers. comm. 2022). *Faxonius virilis* is highly mobile, produces many young, and is tolerant of a wide range of environmental variables making the species a very successful invader (Hazlett 1974; Hamr 2002; Larson and Olden 2011). The virile crayfish competes directly with the Big Sandy crayfish for resources such as food and shelter (Loughman, West Liberty University, West Liberty, West Virginia, pers. comm. 2022). More research is needed to understand the implications of virile crayfish competition on Big Sandy crayfish populations.

2.4 Synthesis

At the time of listing in 2016, the Big Sandy crayfish existed in approximately 582 skm (362 smi) from 21 stream systems in the 3 drainages in the upper Big Sandy River basin: Tug Fork, upper Levisa Fork, and lower Levisa Fork (81 FR 20449-20481). Since 2016, surveys throughout its range have increased our understanding of its current distribution. The most notable expansion of Big Sandy crayfish distribution that has been reported is in the upper Levisa Fork, where surveys have documented the species approximately 18.0 skm (11.2 smi) downstream of an occurrence record from 2002 (Jones et al 2009; VDWR 2023). The species currently exists in 600 skm (373 smi) throughout its range. These new detections indicate an increase in the species' redundancy since listing.

Primary threats to the Big Sandy crayfish throughout its range are land-disturbing activities that increase erosion and sedimentation and decrease overall water and stream habitat quality. Identified sources of ongoing erosion and sedimentation that occur throughout the range of the species include active surface coal mining, timber harvesting, unpaved roads, gas and oil development, road construction, offroad vehicle recreation, and stream modifications that cause channel instability (81 FR 20449-20481). These threats are expected to continue or increase into the future. Existing regulatory mechanisms are not sufficient to ameliorate these threats in the absence of ESA protections.

The majority of extant subpopulations of Big Sandy crayfish are expected to be stable. However, the lower Levisa Fork drainage population may have a greater chance of extirpation in the near term due to fewer occupied streams, low abundances, and the increased intensity of sediment loads into the occupied streams (R. Aulick, U.S. Fish and Wildlife, Davis, WV, pers. obs., 2021; Loughman, West Liberty University, West Liberty, West Virginia, pers. comm. 2022). For all populations, sediment inputs will continue to degrade Big Sandy crayfish habitat by eliminating

interstitial spaces within the substrate if actions to ameliorate habitat loss and degradation are not implemented effectively. The elimination of habitat due to sedimentation will decrease the overall diversity and abundance of resources available to the Big Sandy crayfish.

Climate change, invasive species, and spills may influence the status of the species in the future, if not addressed sufficiently.

Based on our review of the status of the species, information regarding threats to the species throughout its range, and the lack of mechanisms to reduce these threats, we recommend that the species remain listed as "threatened."

3.0 RESULTS

3.1 Recommended Classification:

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist** (*Indicate reasons for delisting per 50 CFR 424.11):*
    ____ *Extinction*
    ____ *Recovery*
    ____ *Original data for classification in error*
__X__ **No change is needed**

3.2 New Recovery Priority Number: No change

The Recovery Outline presents the Service's rationale for assigning a recovery priority number of 11C (Service 2018). The information presented in the Recovery Outline remains current, relevant, and valid; thus, no change is proposed to the recovery priority number.

RECOMMENDATIONS FOR FUTURE ACTIONS

The primary recommendation is for the Service to engage partners across Kentucky, Virginia, and West Virginia and develop a draft Recovery Plan, complete with detailed, prioritized recovery actions. A Recovery Implementation Strategy should be developed and kept current through regular updates.

Recovery efforts should focus on avoiding and minimizing disturbances and degradation of streams where the Big Sandy crayfish exists (section 2.3.2.1); developing a spill prevention and remedial action plan (section 2.3.2.5); developing captive holding/propagation techniques; and conducting additional research on the species to address key information gaps, such as life history and water quality parameters that are necessary to support viable populations of the species (section 2.3.1.1). Additional surveys in understudied streams or stream reaches, particularly in the lower Levisa Fork and the lower reaches of the Tug Fork will also be beneficial to fill important data gaps.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of the BIG SANDY CRAYFISH (*Cambarus callainus*)

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

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

Appropriate Listing/Reclassification Priority Number, if applicable: Not applicable

REGIONAL OFFICE APPROVAL

Approve SHARON MARINO Digitally signed by SHARON MARINO Date: 2025.02.07 16:50:24 -05'00'
Assistant Regional Director, Ecological Services