U.S. Fish & Wildlife Service

Idaho Fish and Wildlife Office

Snake River physa

(Physa (Haitia) natricina)

5-Year Review: Summary and Evaluation

U.S. Fish and Wildlife Service

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5-YEAR REVIEW

Species reviewed: Snake River physa snail (*Physa (Haitia) natricina*)

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5-YEAR REVIEW
Snake River physa snail/*Physa (Haitia) natricina*

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional or Headquarters Office: Pacific Region Office, Portland, Oregon. (503) 231-6120.

Lead Field Office: Idaho Fish and Wildlife Office, Boise, Idaho. (208) 378-5243.

Cooperating Field Office(s): La Grande Field Office, La Grande, Oregon. (541) 962-8509.

Cooperating Regional Office(s): NA

1.2 Methodology used to complete the review:

In preparing this draft document, we used information contained in numerous technical reports, peer reviewed scientific studies related to the species, Section 7(a) of the Endangered Species Act (Act) consultation documents such as biological assessments and opinions, and monitoring and survey data collected by the U.S. Bureau of Reclamation (USBOR), the Idaho Power Company (IPC), Montana State University, and other partners.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review:
March 6, 2012. Endangered and Threatened Wildlife and Plants; 5-Year Status Reviews of 46 Species in Idaho, Oregon, Washington, Nevada, Montana, Hawaii, Guam, and the Northern Mariana Islands. 77 FR 13248.

1.3.2 Listing history

<u>Original Listing</u>
FR notice: 57 FR 59244
Date listed: December 14, 1992
Entity listed: Snake River physa snail (*Physa natricina*)
Classification: Endangered

1.3.3 Associated rulemakings: NONE

1.3.4 Review History: NONE

1.3.5 Species' Recovery Priority Number at start of 5-year review:
Recovery Priority Number of 5c (high degree of threat/ low recovery potential/ potential for conflict with economic activities)

1.3.6 Recovery Plan or Outline

Name of plan or outline: Snake River Aquatic Species Recovery Plan
Date issued: December, 1995
Dates of previous revisions, if applicable: NA

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?

__x_ ***Yes***
____ ***No***

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

____ ***Yes***
__x_ ***No***

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

____ *Yes*
__x_ ***No***

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

Within the Recovery Plan, we state that the Snake River physa snail (Snake River physa) may be reclassified or recovered by implementing various conservation measures that preserve and restore mainstem Snake River and tributary cold-water spring habitats. We also state that recovery will be based on detection of increasing, self-reproducing colonies at pre-selected monitoring sites within each species recovery area for a 5-year period.

Status

The existing Snake River Aquatic Species Recovery Plan does not contain recovery criteria specific to the Snake River physa. The existing criteria were written to encompass all five aquatic snail species listed within the Recovery Plan and we no longer consider them to be objective or measurable. Since completion of the 1995 Snake River Aquatic Species Recovery plan, we have learned additional information about this species, including where it has been found and its habitat preferences. For example, after the 1992 listing, it wasn't until 2006 that the species was identified again in the Snake River. Given this new information, we recommend that the recovery criteria be revised specific to Snake River physa to include our current knowledge for the species.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

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

The Snake River physa was formally described by Taylor (Taylor 1988, pp. 67-74; Taylor 2003, p. 147), from which the following descriptive characteristics are taken. The shells of adult Snake River physa may reach 7 millimeters (mm (0.28 inches (in))) in length with 3 to 3.5 whorls, and are amber to brown in color and ovoid in overall shape. The aperture (main opening of the shell) whorl is inflated compared to other Physidae in the Snake River; the aperture whorl being greater than or equal to one half of the entire shell width. The growth rings are oblique to the axis of coil at about 40 degrees and relatively course, appearing as raised threads. The body is nearly colorless, but tentacles have a dense black core of melanin in the distal (remote from the point of attachment) half. The penal complex lacks pigmentation although the penal sheath may be opaque. The tip of the penis is simple (not ornamented).

Freshwater pulmonate snail species such as the Snake River physa do not have gills, but absorb oxygen across the inner surface of the mantle (outer wall of the mollusk's body that encloses the internal organs) (Dillon 2006, p. 252). The walls of the mantle are heavily vascularized (filled with blood vessels), and air is drawn into the mantle cavity via expansion and contraction of the mantle muscles (Vaughn *et al.* 2008, entire). Freshwater pulmonates usually carry an air bubble within the mantle as a source of oxygen, replenished via occasional trips to the surface. However some freshwater pulmonate species do not carry air bubbles; oxygen instead diffuses from the water directly into their tissues across the surface of the mantle (Dillon 2006, p. 252). This mode of respiration is likely the one used by the Snake River physa. Since this species lives in moderately swift current, individuals that would release from substrates to replenish air at the surface would likely be transported some distance downstream away from their colony and habitat of choice, possibly into unsuitable habitat.

The protean physa (*Physella virgate*) has been observed to move and remain out of the water for up to 2 hours in reaction to chemical cues given off by crayfish foraging on other nearby protean physa (Alexander and Covich 1991, p. 435). The Snake River physa may have the same capability for out-of-water survival, though the fact that the species has rarely been collected in shallow water (less than 0.30 meters (m) (0.98 feet (ft))) and has been found in greatest abundance at depths greater than or equal to 1.5 m (4.9 ft) (Gates and Kerans 2010, p. 23), indicates that the Snake River physa does not routinely occur in shallow water or spend extended periods out of water.

The diet preferences of Snake River physa are not known. Species within the family Physidae live in a wide variety of habitats and exhibit a variety of dietary preferences. Physidae from numerous studies consumed materials as diverse as aquatic macrophytes, benthic diatoms (diatom films that primarily grow on rock surfaces, also called periphyton), bacterial films, and detritus (Dillon 2000, pp. 66-70). The tadpole physa (*Physa gyrina*), which co-occurs with Snake River physa in the Snake River, consumes dead and decaying vegetation, algae, water molds, and detritus (DeWitt 1955, p. 43; Dillon 2000, p. 67). The Snake River physa likely has feeding patterns similar to the tadpole physa.

Snake River physa have not yet been cultured and studied in the laboratory, and the species' reproductive biology has not been studied under natural conditions. Another physid species, the acute bladder snail (*Physa acuta*), reaches sexual maturity at between 6 to 8 weeks at 22-24 degrees Celsius (°C) (71.6-75.2 degrees Fahrenheit (°F)) in laboratory conditions (Escobar *et al.* 2009, p. 2792). In another study, Dillon *et al.* (2004, p. 65), reported a mean fecundity of 39 hatchlings per pair, per week for acute bladder snail. It is not known whether the Snake River physa exhibits reproductive output similar to the acute bladder snail.

All freshwater pulmonates are reported to be able to reproduce successfully by self-fertilization (Dillon 2000, p. 83). While self-fertilization (selfing) in pulmonates can be forced under laboratory conditions by isolating individual snails, there is considerable variation within and among pulmonate genera and species in the degree of selfing that occurs in natural populations. Selfing and its implications for genetic variation and fitness are unknown for Snake River physa.

Water temperature requirements of Snake River physa have not been identified. Gates and Kerans (2010, p. 21) reported a mean water temperature of 22.6 °C (72.7 °F) for sites occupied by the species at the time of sampling (in August and October), but it is not known if this represents an optimal range. Snake River physa were collected in the Bruneau arm of C.J. Strike Reservoir and in the Snake River when water temperatures were averaging 23.4°C (74.1 °F) (Winslow 2013, *in litt.*). The maximum temperature for cold water aquatic life in Idaho is 22 °C (71.6 °F). Based on available information, Snake River physa appear to be able to tolerate water temperatures slightly above the cold water standard of 22 °C (71.6 °F), although their upper temperature limit has not been identified. Conversely, water temperatures below 10.0 °C (50 °F) are known to inhibit reproduction in the tadpole physa (DeWitt 1955, p. 43). Springs originating from the Eastern Snake River Plain Aquifer (ESPA) flow at temperatures from 14 to 16 °C (57.2 to 60.8 °F) year around. Extensive monitoring and surveys in these cold-water springs for the Bliss Rapids snail (*Taylorconcha serpenticola*) and Banbury Springs lanx (*Lanx* n sp.) have never found the Snake River physa, indicating these habitats are not preferred by the Snake River physa. Average dissolved oxygen (DO) measured in occupied Snake River physa habitat has been reported to range from 8.35 to 9.99 milligrams per liter (mg/L) in studies by Gates and Kerans (2010, p. 21) and the USBOR (2013, p. 22).

Onset of egg-laying by physid species appears to be a function of water temperature. McMahon (1975, entire) summarized a range of water temperatures at which egg laying occurred for two species that occur in North America (acute bladder snail and tadpole physa), and one European (common bladder snail [*Physa fontinalis*]) physid species as between 7-13 °C (44.6-55.4 °F) in northern temperate climates. Dillon (2000, pp. 156-170) noted a commonly reported temperature for the onset of gastropod egg-laying (including physid species) as being 10 °C (50 °C). Although the acute bladder snail and tadpole physa are known to occur in the Snake River, neither species is common in habitats preferred by Snake River physa.

In summary, the Snake River physa likely diffuses oxygen from the water directly into its tissues across the surface of the mantle. The diet preference of the Snake River physa remains unknown, but studies of other physid species indicate they may consume macrophytes, benthic diatoms, bacterial films, dead and decaying vegetation, algae, water molds, and detritus. The Snake River physa is likely able to reproduce both sexually and asexually, though implications of selfing on genetic variation and fitness are unknown. Snake River physa have been found in water temperatures above 22 °C (71.6 °F) and have not been found in the cool-water springs that flow into the Snake River.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

While Gates and Kerans (2010, p. 37) helped identify the spatial extent and distribution of Snake River physa downstream of Minidoka Dam at river kilometer mile (RKM) 1086 (river mile 675 (RM)) from 2006 - 2008, their study design did not allow for an estimate of the population's size. Limited survey data from 2006 through 2012 indicates the Snake River physa occurs at relatively low densities (generally less than or equal to 32 individuals per m^2, but up to 64 per m^2 have been collected downstream of Minidoka Dam) and the population trend appears to be stable within the Minidoka reach (RKM 1086-1068 (RM 675-663.5)), though these results apply to only one location at Jackson Bridge (RKM 1077 (RM 669) (USBOR 2013, p. 24; USFWS 2012a, p. 16). There are no studies that the Service is aware of that would allow us to estimate, with any degree of confidence, current abundance estimates or long-term demographic trends for the Snake River physa.

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

Burch (2008, *in litt.*), Burch *et al.* (2010, *in litt.*), and Gates *et al.* (2013, p. 162) positively identified specimens collected below Minidoka Dam from 2006 - 2008 as Snake River physa based on Taylor's shell and soft tissue characters (1988 pp. 67-74; 2003 p. 147). Gates *et al.* (2013, p. 163) also analyzed 15 of 51 live-when-collected Snake River physa museum specimens gathered from Bliss Dam (RKM 901 (RM 560)) downstream to near Ontario, Oregon (RKM 592 (RM 368)), and found that these specimens were genetically similar to Snake River physa collected downstream of Minidoka Dam (RKM 1086 (RM 675)). The Service is not aware of additional studies that have examined Snake River physa genetic diversity between populations.

2.3.1.4 Taxonomic classification or changes in nomenclature:

The Snake River physa (*Physa (Haitia) natricina*)[1] is a pulmonate (having lungs or organs resembling lungs) species, in the family Physidae, order Basommatophora (Taylor 1988, entire; Taylor 2003, entire). The rarity of Snake River physa collections, combined with difficulties associated with distinguishing this species from other physids has resulted in some uncertainties over its status as a separate species. Taylor (2003, entire) presented a systematic and taxonomic review of the family, with Snake River physa recognized as a distinct species based on morphological characteristics he originally used to differentiate the species in 1988. Rogers and Wethington (2007, entire) concluded that the characters described by Taylor in 1988 (pp. 67-72) were within the range of variability observed in *Physa acuta,* and placed Snake River physa as a synonym junior (one of two scientific names referring to the same organism, with *Physa natricina* being more recently described) to *Physa acuta*. Genetic material from early Snake River physa collections was not available when Rogers and Wethington (2007, entire) published their work, thus it did not include an analysis or discussion on the species' genetics.

As part of monitoring required in a 2005 Biological Opinion (USFWS 2005, entire), live snails resembling Snake River physa were collected by the USBOR downstream of Minidoka Dam in numbers sufficient to provide specimens for morphological review and genetic analysis (Gates and Kerans 2010, entire). Using Taylor's description of shell and soft tissue characteristics (1988, pp. 67-74; 2003, p. 147), other scientists (Burch 2008, *in litt.*; Burch *et al.* 2010, *in litt.*; Gates *et al.* 2013, p. 162) were able to positively identify these specimens as Snake River physa. Genetic analysis of these specimens also determined they were distinct from *Physa acuta.* Gates *et al.* (2013, p. 163) also performed similar analyses on 15 of 51 live-when-collected Snake

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[1] While we recognize Taylor's (2003) classification of Snake River physa under genus *Haitia,* we still refer to the genus *Physa* given it is the listing entity and was most recently referenced by Gates *et al.* (2013). Given the inconsistencies and fluidity of Physidae classification, nomenclature for other Physidae follows Wethington and Lydeard (2007).

River physa museum specimens collected between 1998 and 2002 in the Snake River reaches from Bliss Dam (RKM 901 (RM 560)) downstream to near Ontario, Oregon (RKM 592 (RM 368)), and found that these specimens were genetically similar to Snake River physa collected downstream of Minidoka Dam (RKM 1086 (RM 675)) and genetically distinct from *Physa acuta*. The Service regards the conclusions from Burch (2008, *in litt.*), Burch *et al.* (2010, *in litt.*), and Gates *et al.* (2013, entire) to be the most thorough and recent determinations of Snake River physa as a distinct taxon which included an examination of both morphological and genetic components.

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

Existing populations of the Snake River physa are known only from the Snake River in central and south-southwest Idaho (and a small portion of Oregon; see Figure 1), with the exception of two specimens recovered in 2002 from the Bruneau River arm of C.J. Strike Reservoir (Keebaugh 2009, p. 123). Fossil evidence indicates this species was much more widespread during the Pleistocene-Holocene in lakes and rivers of northern Utah and southeastern Idaho, and as such, is a relict species from Lake Bonneville, Lake Thatcher, the Bear River, and other lakes and watersheds that were once connected to these water bodies (Frest *et al.* 1991, p. 3; Link *et al.* 1999, pp. 251-253).

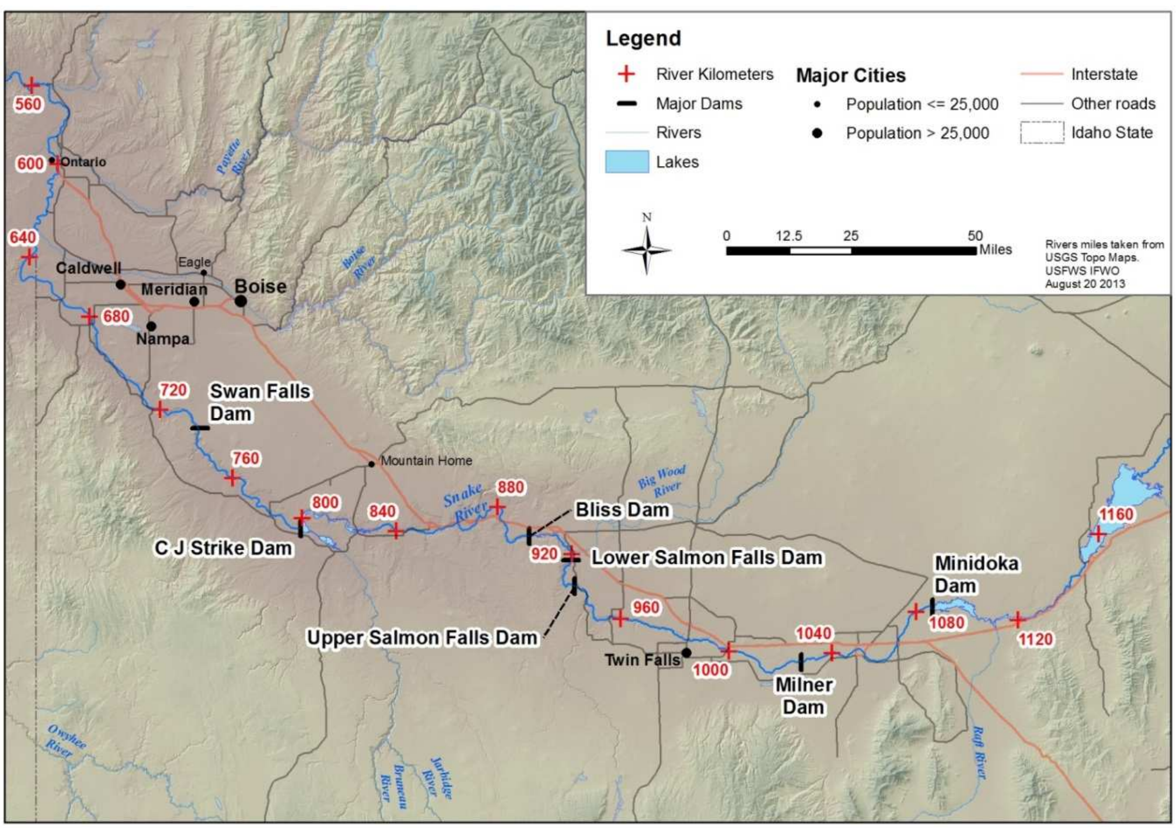

Figure 1: The Snake River encompassing the known range, from approximately Minidoka Dam, Idaho, to Ontario, Oregon, of the Snake River physa.

In the Snake River Species Aquatic Recovery Plan, the Service (1995, p. 8) reported that the "modern" range of the Snake River physa extended within the Snake River from Grandview (RKM 784 (RM 487)) to the Hagerman reach (RKM 922 (RM 573)), with a possible colony downstream of Minidoka Dam (RKM 1086 (RM 675)). Since the time of listing in 1992, the first known collection of Snake River physa in the Snake River was in 2006, when live specimens were collected by USBOR in the Minidoka reach (RKM 1086-1068 (RM 675-663.5)). Surveys conducted by the USBOR from 2006 through 2012 (Gates and Kerans 2010. entire; Gates *et al.* 2013, entire; USBOR 2013, p. 18), and subsequent analysis in 2009 of collections by the IPC between 1995 and 2003 (Keebaugh 2009, entire) have established the Snake River physa's current distribution to be from RKM 592 (RM 368) near Ontario, Oregon, upstream to Minidoka Dam RKM 1086 (RM 675)). The site near Ontario, Oregon is approximately 206 kilometers (km) (128 miles (mi)) downstream from the species previously recognized downstream-most extent of distribution. The additional site in the Bruneau River arm of C.J. Strike Reservoir was identified by Gates and Kerans (2011, p. 10) when they confirmed that shell morphology, diagnostic of Snake River physa, matched that of specimens with similar morphology also confirmed as Snake River physa by DNA analysis. Within this range, live Snake River physa have been collected in two general areas: 1) the reach below Lower Salmon Falls Dam (RKM 922 (RM 573)) downstream to approximately Ontario, Oregon (RKM 592 (RM 368)), and 2) in the Minidoka reach (RKM 1086-1068 (RM 675-663.5)). Within this 494 km (307 mi) range, the species remains rare with only 385 confirmed live-when-collected specimens taken over a 53-year period between 1959 and 2012.

It is important to note that while live Snake River physa have been collected from the same survey transects in successive years (2006-2012) downstream of Minidoka Dam (Gates and Kerans 2010, p. 24; USBOR 2013, p. 24), the species has not been regularly or reliably located throughout the rest of its range. Snake River physa have not been found in the reaches between Lower Salmon Falls Dam and the Minidoka reach (RKM 922-1068 (RM 573- 663.5)), although surveys in this area have been lacking. Snake River physa have not been collected in the area of the type locality (RKM 916-917 (RM 569-570)) described by Taylor since 1988. Taylor's 1959, 1988 (1982, entire; 1988, pp. 67-74), and Frest and others' (1991, p. 8) 1988 collections are the only known live, confirmed collections from the type locality. The Snake River physa were first documented downstream of C.J. Strike Reservoir during the 2009 inspection of samples collected by IPC from 1995 - 2003 (Keebaugh 2009, entire). In his review of over 19,000 physids collected from IPC's 917 collection events, Keebaugh (2009, p. 4) identified 52 live-when-captured individuals in 34 collection events matching the morphological characteristics of Snake River physa (Gates and Kerans 2011, p. 10). A subset (15 individual snails) was confirmed to be Snake River physa through genetic analysis (Gates and Kerans 2011, p. 4; Gates *et al.* 2013, p. 163).

As part of an Endangered Species Act (Act) consultation regarding the relicensing of Swan Falls Dam, in 2010 IPC sampled for Snake River physa (60 samples total) at 12 locations in proximity to where the species had been previously collected near Walters Ferry to Swan Falls Reservoir (RKM 711 – 755 (RM 442 – 469). These surveys failed to collect live Snake River physa specimens (IPC 2011, pp. 11 and 167) (IPC 2012, *in litt.*). While this indicates the species is likely not found in abundance within this reach of its range, survey effort has been limited. In addition, a portion of this sampling effort was conducted within Swan Falls Reservoir, which comprises more lentic (standing to relatively still water) habitat conditions that do not appear to be preferred by Snake River physa (see Section 2.3.1.6 - Habitat or ecosystem conditions below). The 1995-2003 IPC collections also contained 12 live when collected Snake River physa obtained between C.J. Strike and Swan Falls Dams. Unlike survey efforts associated with Swan Falls Dam relicensing, follow-up surveys for the Snake River physa have not been conducted from C.J. Strike Dam downstream to Swan Falls Reservoir at RKM 755 (RM 469) since these 1995-2003 collections.

At this time the Service considers the colonies downstream of Minidoka Dam and spillway as the upstream-most extent of the species' current range. Previous identification of Snake River physa from surveys upstream of Minidoka Dam by Pentec Environmental (1991, *in litt.*) and Frest (1991, *in litt.*) at RKMs 1191 and 1205 (RMs 740 and 749) had not been confirmed through genetic analysis. In addition, 2011 surveys by the USBOR upstream of Minidoka Dam, and downstream of American Falls Dam (approximately RKM 1135 - 1144 (RM 705 - 711)) have failed to yield any live Snake River physa or its shells (Newman 2012, *in litt.*).

In summary, the currently confirmed range of the Snake River physa is from RKM 1086 (RM 675) at Minidoka Dam downstream to RKM 592 (RM 368) near Ontario, Oregon. Within this 494 km (307 mi) range the species is generally rare and occurs in patchy distribution, with only 385 confirmed live-when-collected specimens taken over a 53-year period between 1959 and 2012. The species highest abundance and densities are currently found in the 18.5 km (11.5 mi) river segment downstream of Minidoka Dam. Despite limited efforts to sample for the species from locations where it's been previously collected, Snake River physa has not been reliably collected outside of the Minidoka reach.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Based on the most recent findings (Gates and Kerans 2010, entire) of the Snake River physa's distribution and habitat preferences, the conservation needs of the species includes instream conditions that produce or sustain beds of pebble to gravel, and possibly cobble to gravel, that are largely free of substrates finer than gravel which can fill in the interstitial spaces between gravel. Given the lack of fine substrates within their preferred habitat, these preferred habitat areas are also largely free of macrophytes (USFWS 2012a, Appendix A). Macrophyte beds can reduce water velocity, causing fines such as sand, silt, and clay to fall out of the water column, potentially embedding or covering Snake River physa habitat (USFWS 2012a, p. 68).

In general, the locations of live, confirmed specimens of Snake River physa have been most frequently recorded from the free-flowing reaches of the Snake River downstream of the following dams: Minidoka Dam, Lower Salmon Falls Dam, Bliss Dam, C.J. Strike Dam, and Swan Falls Dam. Free-flowing reaches are defined here as areas of the Snake River where water velocities generally keep gravel and pebble beds free of fine sediments and subsequent macrophyte growth, and habitats at the range of depths (0.5 m to 3 m) where Snake River physa has been found. Maintaining these areas of suitable habitat for the Snake River physa in these free-flowing reaches of river is reliant on maintaining suitable water quality conditions, particularly temperature, fine sediments, and nutrient load, to minimize macrophyte growth (USFWS 2012a, p. 68).

Gates and Kerans detailed study (2010) of Snake River physa in the Snake River reach downstream of Minidoka Dam characterized Snake River physa habitat as run, glide, and pool habitats with a moderate mean water velocity (0.57 m/second (1.87 ft/ second)). The mean water depth where live Snake River physa were collected averaged 1.74 m (5.71 ft), with most snails found at depths of 1.5 to 2.5 m (4.9 to 8.2 ft). Depths in which all Snake River physa were collected ranged from less than 0.5 m (1.6 ft) to over 3.0 m (9.8 ft), and the highest density (12 or more) collected per square meter (m^2) were at depths greater than 1.5 m (4.9 ft). Eighty percent of samples containing live Snake River physa were located generally in the middle of the river and away from the margins (Gates and Kerans 2010, p. 20); most typically in deeper water habitats.

In an effort to clarify Snake River physa habitat use for describing distribution, the Service, in coordination with IPC biologists, conducted an analysis (USFWS 2012a, Appendix A) of substrate selection in areas where the species had previously been found. This analysis also looked at substrate composition and distribution in the Snake River, including the type locality. The results indicated that Snake River physa were found to strongly select for substrates ranging in size from gravel to pebble, and possibly from gravel to cobble with minimal macrophyte growth. This substrate selection is somewhat different than Taylor's 1982 (p. 2) description of boulder to gravel substrates, with his specimens being collected from boulders. This preference for gravel to pebble, and possibly gravel to cobble, however, are consistent in both the stretch of river between C.J. Strike Dam (RKM 795 (RM 494)) to near Ontario, Oregon (RKM 592 (RM 368)) and the Minidoka reach (RKM 1086-1068 (RM 663.5 – 675)). These two sections of the Snake River are occupied by the Snake River physa but are separated by over 322 river km (200 river mi) (USFWS 2012a, p. 64).

Gravel and pebble were the most common substrates reported by Gates and Kerans (2010, p. 23) in the Minidoka reach (USFWS 2012a, p. 63). This suggests that the existence of relatively large, contiguous areas of this habitat type in this reach may be one factor contributing to the comparatively high densities and abundance of Snake River physa which occur here. Densities were generally less than or equal to 32 individuals per m^2 (approximately 3 individuals per ft^2), but 3 samples had up to 40 to 64 individuals per m^2 (3.7 to 6.0 individuals per ft^2). Although Gates and Kerans (2010, p. 37) documented relatively high densities of Snake River physa in their study area, they also concluded that Snake River physa occurred in a diffusely distributed population, and suggested that the species rarely exhibits high density colony behavior.

Dams can act as sediment traps, reducing fine sediment loading in rivers downstream of the dam (Poff *et al.* 1997, pp. 772-774). The American Falls Dam (RKM 1149 (RM 714)) and Minidoka Dam (RKM 1068 (RM 675)), which are both upstream of the largest known population of Snake River physa, likely act as effective sediment traps (Newman 2011, *in litt.*). In addition, Lake Walcott (reservoir behind Minidoka Dam) is largely operated as run of river (operates based on available streamflow with limited storage capability), meaning that bottom sediments at the dam's face are typically not mobilized. Water leaving the power plant and passing through the spillway gates is relatively free of fine sediment and provides little or no sediments that could embed cobble substrates and support macrophytes.

In addition, Minidoka Dam is normally operated so that the Snake River downstream somewhat mimics a natural hydrograph of a lowland western river, with flows increasing in spring, peaking during summer, and tapering off through the fall; with the primary departure from a natural hydrograph being that high flows are maintained downstream of Minidoka Dam well into September (USFWS 2012b, p. 15). The effect of this high and prolonged summer flow regime is to keep the pebble and gravel beds relatively free of fine sediment during the period of highest insolation and summer temperatures, resulting in reduced presence of macrophyte growth throughout the Minidoka reach where Snake River physa can be encountered (USFWS 2012a, p. 15). Flow operations at Swan Falls Dam are inverse from those at Minidoka Dam, with flows highest in winter, and lowest in summer (usually July and August) during the period when macrophyte production and growth would be the highest (USFWS 2012a, p. 15). Proliferation of macrophytes on cobble/ gravel beds downstream of Swan Falls Dam have been attributed to nutrient loading and high sediment loads passing Swan Falls Dam (Groves and Chandler 2005, pp. 479-480). Compared to the number of Snake River physa found by Gates and Kearns (2010) downstream of Minidoka Dam, the IPC collected far fewer Snake River physa downstream of Swan Falls Dam per sampling effort[2], which may be in part attributable to low summer flows, higher sediment load combined with high nutrient loads, and therefore a higher percentage of macrophytes downstream of Swan Falls Dam (USFWS 2012a, p. 16).

The section of the Snake River between Lower Salmon Falls Dam (RKM 922 (RM 573)) and C.J. Strike Reservoir (RKM 795 (RM 494)), which includes the type locality reach, does not appear to contain large areas of preferred habitat (pebble to gravel to cobble) for the Snake River physa (USFWS 2012a, p. 14). Even though sampling for Snake River physa has not been extensive throughout this reach, its history of low detections in this section suggests that under the current habitat conditions, the probability of encountering Snake River physa within this reach will likely remain low into the future (USFWS 2012a, p. 14).

Between C.J. Strike Dam (RKM 795 (RM 494)) and Swan Falls Dam (RKM 736.6 (RM 457.7)), there were 12 live when collected specimens of Snake River physa collected in 2001 and 2002 (IPC 2012, *in litt.*). C.J. Strike Dam is operated in a load-following mode in response to electricity demand (USFWS 2004, p. 20). While we have limited information regarding Snake River physa habitat conditions downstream of C.J. Strike Dam, given existing dam operations (load-following versus irrigation water release) we anticipate Snake River physa habitat conditions to be more similar to the habitat conditions downstream of Swan Falls Dam (sediment, extensive macrophytes) as opposed to downstream of Minidoka Dam (pebble to cobble, limited macrophytes).

Data collected to date indicate the conditions of sites where Snake River physa have been collected are characterized by swift current, where the river transitions from lotic (free-flowing)

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[2] 4.8 times more Snake River physa were collected downstream of Minidoka Dam for approximately double the sampling effort, compared to what was collected downstream of Swan falls Dam (USFWS 2012a, pp. 61-62).

to more lentic (standing water) environments. In contrast, the two specimens of Snake River physa found in the reservoir pool of the Bruneau River arm of C.J. Strike Reservoir is in an area usually characterized by very slow moving lentic conditions. Little is known of the species' distribution or habitat in the Bruneau River arm of C.J. Strike Reservoir, compared to habitat conditions where it has been found elsewhere in the Snake River.

In summary, Snake River physa are generally found in free-flowing Snake River reaches characterized by gravel to pebble-sized and possibly cobble-sized substrates, where these substrate types stay relatively free of fines and macrophyte growth. The species is rare in Snake River reaches with widely scattered, low proportions of cobble to gravel substrates, as in the reach between C.J. Strike Reservoir (RKM 795 (RM 494)) and Lower Salmon Falls Dam (RKM 922 (RM 573)). Snake River physa is patchily distributed in the free-flowing reaches from C. J. Strike Dam downstream to near Ontario, Oregon, but it is found at higher densities downstream of Minidoka Dam.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):

At the time when the Snake River physa was classified endangered on December 14, 1992 the Service identified the following threats to the species: construction of new hydropower dams, operation of existing hydropower dams, water quality degradation, water diversions and groundwater withdrawals for agriculture and aquaculture, small hydroelectric development, lack of State regulations, pollution regulations, Federal consultation regulations, and competition with the non-native New Zealand mudsnail. The information contained in the following sections updates what the Service stated at the time of listing. Additionally, factors that may affect the Snake River physa seldom act independently, but rather interact synergistically and/or cumulatively, and should be regarded holistically instead of as separate threats.

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

At the time of listing, the threats to the Snake River physa associated with present or threatened destruction, modification or curtailment of its habitat or range included several proposed large and small scale hydroelectric developments, peak-loading operations of existing hydroelectric projects, degraded water quality, and water diversions and groundwater withdrawals (57 FR 59251-59253). Below we have provided an updated analysis of threats of the present or threatened destruction, modification or curtailment of its habitat or range.

<u>Construction of New Hydropower Dams on the Mainstem Snake River</u>

Proposed hydroelectric projects within the range of Snake River physa as discussed in the 1992 final listing rule were never approved for construction. The A.J. Wiley project and Dike Hydro Partners preliminary permits have lapsed; the Kanaka Rapids, Empire Rapids, and Boulder Rapids permits were denied by the Federal Energy Regulatory Commission (FERC) in 1995. There was a notice of surrender of the preliminary permit for the River Side Project in 2002 and two other proposed projects, the Eagle Rock and Star Falls Hydroelectric Projects, were denied preliminary permits by the FERC. In 2003, a notice was provided of surrender of the preliminary permit for the Auger Falls Project. Information provided by the State of Idaho indicates that all proposals and preliminary permits for the construction of new dams along the mid-Snake River have either lapsed or been denied by the FERC (Caswell 2007, *in litt.*). Today, the Service is unaware of any small hydroelectric development proposals within the species known range that would threaten the Snake River physa.

While there are no immediate or specific plans for dam and reservoir development within the range of the Snake River physa, the Idaho Water Resource Board (IWRB) has proposed the need to consider such development in the future. Development of specific new dams or reservoirs within the Snake River is not mentioned in the 2012 Idaho State Water Plan, though that plan does state that future surface water development will continue to play an important role in the State's future (IWRB 2012, pp. 18-20), and the "existing capacity is insufficient to provide the water supply and management flexibility needed…", and that "New Snake River surface storage projects should be investigated and constructed if determined to be feasible" (IWRB 2012, p. 55). Any water development/management activities that would directly alter lotic habitats (e.g., construction of new reservoirs), or reduce flows within the Snake River will pose a threat to the free-flowing river habitats important to the species.

<u>Operation of Existing Dams</u>

The impacts from the presence of dams and reservoirs, and subsequent alterations of flows are well documented and generally known to have negative impacts on macroinvertebrate species (Fisher and LaVoy 1972, p. 1473; Kroger 1973, pp. 479-480; Brusven *et al.* 1974, pp. 75-76; Gislason 1980, pp. 83-85; Gersich and Brusven 1981, p. 235; Armitage 1984, pp. 141-142; Brusven 1985, pp. 167-168; Poff *et al.* 1997, pp. 776-777). In the following section, we will discuss the threat of the operation of existing dams on the Snake River physa through two avenues; daily fluctuations of water levels due to hydropower operations (*Peak-Loading*), and; seasonal fluctuations of water levels due to irrigation water delivery (*Dam Operations for Irrigation Purposes*).

Peak-Loading

"Peak-loading (the operation of dams that are directly in response to electricity demands) is a frequent and sporadic practice that results in dewatering mollusk habitats in shallow, littoral shoreline areas" (57 FR 59252). Peak-loading operations within the range of the Snake River physa occur at the Bliss Dam (RKM 901 (RM 560)), Lower Salmon Falls Dam (RKM 922 (RM 573)), C.J. Strike Dam (RKM 789 (RM 490), and Swan Falls Dam (RKM 736.6 (RM 457.7)) (USFWS 2004, pp. 19, 20; USFWS 2012a, p. 5).

Irving and Cuplin (1956, entire) provided information on the effects that hydropower peak-loading had on the aquatic organisms of the Mid-Snake River (approximately RKM 943 to RKM 711 (RM 586 to RM 442)). Their work showed a pronounced decrease in number (reduced by 84 percent) and biomass (reduced by 92 percent), of benthic invertebrates in the shallow tailwaters of both the Lower Salmon Falls and Bliss Dams, as compared to reaches of the river where flows were maintained at more natural levels.

Subsequent studies have also reported negative impacts to benthic invertebrates such as stranding and desiccation, and all of these studies inferred or noted reduced abundance of benthic invertebrates in de-watered areas (Fisher and LaVoy 1972, p. 1472; Kroger 1973, p. 478; Brusven *et al.* 1974, p. 78; Brusven and MacPhee 1976, p. iv). Members of the family Physidae are a relatively mobile group of aquatic snails, and being members of the "lung-breathing" Class Pulmonata, are typically capable of some limited respiration out of aquatic habitats. Under certain conditions, members of the aquatic pulmonates, and notably the Physidae, may actively leave the water to avoid predators (Dillon 2000, pp. 307-309). Covich *et al.* (1994, p. 287) observed protean physa remain out of the water for hours and days to avoid predation. Although a number of these snails died from desiccation, about 87 percent survived. Similarly, it is plausible that physids may be able to re-enter, or follow water should their habitats suddenly be dewatered. Since the Snake River physa primarily occurs in deeper habitats, it is less likely to be within the regularly dewatered zone caused by peak-loading from hydroelectric dams. However, peak-loading likely limits available habitats for Snake River physa in regularly de-watered areas of the river channel, restricting them to deeper portions that are located well within continuously watered habitats.

At Bliss and Lower Salmon Falls Dams, peak-loading operations can result in river stage changes downstream of the dams of up to 1.5 to 1.8 m (5 and 6 ft) per day for the two dams respectively (USFWS 2012b, p. 9). As stated above, the Snake River physa does not appear to be common downstream of Bliss Dam and Lower Salmon Falls Dam. Downstream of C.J. Strike Dam, fluctuations up to 1.2 m (4 ft) in the tailwaters may result during each peak-loading episode associated with loading operations (USFWS 2004, p. 20). Given the sparse occurrence data of Snake River physa downstream of C.J. Strike Dam, and the rarity of the species in this reach, it is difficult to assess the threat of peak loading from C.J. Strike Dam on Snake River physa.

While peak-loading operations occur to a certain extent below Swan Falls Dam (RKM 736.6 (RM 457.7); its primary operation is to re-regulate flows from C.J. Strike Dam, which is located approximately 52 RKM (32 RM) upstream), its operation has been determined not to rise to the level of impacting the Snake River physa in a manner that would result in population level effects, though low summer flows, nutrient loading, and sediment deposition are considered the most significant threat to the species downstream of this dam (USFWS 2012a, p. 43). If habitat conditions worsen downstream of Swan Falls Dam, additional impacts to the species habitat may occur, though at this time, without further information it is difficult to project if this will occur and how it would affect the species persistence in this area (USFWS 2012a, p. 43).

Dam Operations for Irrigation Purposes

Unlike Snake River dams whose operations require peak-loading in response to electricity demand, the primary purpose of other Snake River dams is to provide storage water for irrigation (e.g. Minidoka Dam, Milner Dam). One of the primary differences between these two operational regimes on Snake River physa habitat is that dams operated for irrigation purposes can dewater large areas of river habitat for a much greater duration of time than for peak-loading operations. Therefore the potential effects of irrigation dewatering on the Snake River physa possess similarities to those experienced during peak-loading operations (see above under *Peak-*

Loading). However, whereas peak-loading entails more frequent, short-term dewatering episodes, irrigation management imposes infrequent (e.g., seasonal) but extended periods of dewatering, often dewatering larger benthic areas.

The most robust known population of Snake River physa occurs in 18.5 km (11.5 mi) of the Snake River downstream of Minidoka Dam (RKM 1086 (RM 675)), which is operated by the USBOR. This dam is operated to provide irrigation water during summer months, so summer discharges are kept at a higher rate than during the winter months, and therefore the river below the dam mimics more of a natural hydrograph with flows increasing in spring, peaking during summer, and tapering off through the fall. Downstream of Minidoka Dam, Snake River physa have been found predominately in permanently watered habitat greater than 1.2 m (3.9 ft) in depth (Gates and Kerans 2010, p. 4). In addition, Gates and Kerans (2010, p. 5) found that even after 5 months of water immersion of the littoral zone during elevated irrigation flows, most mollusk species were more commonly recorded in deeper areas of the channel, those habitats watered year-round. It is possible that the area where this population of Snake River physa occurs has experienced consistent seasonal dewatering (4-6 months/ year) of approximately 30 percent of the riverbed since 1910, the year Minidoka Dam began diverting flows for irrigation (Gates and Kerans 2010, p. 9).

USBOR has committed to a minimum flow of 11.2 cubic meters per second (cms) (400 cubic feet per second (cfs)) outflow from Minidoka Dam, so the deepest portions of the riverbed remains submerged year round (USFWS 2005, p. 27). This is important as the Snake River physa is mostly found within the deepest portions of the Snake River within this reach. If this minimum flow requirement was removed, and flows during winter fell below this minimum, additional portions of the riverbed would be exposed to freezing temperatures. This would further impact the only known robust population of Snake River physa.

Substrate composition was also found to significantly differ between watered and dewatered sampled habitat downstream of Minidoka Dam, with more silt occurring in the seasonally dewatered areas of the river bed (Gates and Kerans 2010, p. 36), which is not a suitable substrate for the Snake River physa. Although Snake River physa have continued to persist in this reach, continued dam operations at Minidoka Dam likely limit suitable habitat potentially available for the species.

There are other dams within the range of the species that divert water out of the Snake River for irrigation purposes. During low-water years Milner Dam (RKM 1028.5 (RM 639.1)) diverts all measurable flows from the river during the irrigation season to provide water to fulfill nonfederal water rights holdings for agriculture (USFWS 2005, p. 29; IWRB 2012, pp. 42-48; see Figure 2). This results in approximately 2.6 km (1.6 mi) of the Snake River immediately downstream of Milner Dam being cut off from river flows, some of which are put back into the stream channel further downstream, via a bypass (irrigation) canal through a hydroelectric plant. Milner Dam has been in operation since 1905 (Yost 2013, *in litt.*), meaning impacts related to reduced or no river flow have occurred here for over a century. Water quality downstream of Milner Dam is also substantially compromised since a significant proportion of the source water downstream of the dam is from irrigation return flows (Clark *et al.* 1998, pp. 8, 18). This reach of the Snake River is documented to be water quality limited until significant volumes of groundwater enter into the river from the ESPA in the Thousand Springs to King Hill area ("north-side springs"; approximately RKM 940-982 (RM 584-610)) (Clark *et al.* 1998, pp. 18-19). While it is unknown what the status of Snake River physa is between Milner Dam and Lower Salmon Falls Dam (the next Snake River dam downstream of Milner Dam) due to the lack of surveys, the reduced water quality and poor river habitat condition in this reach would not be expected to support the species.

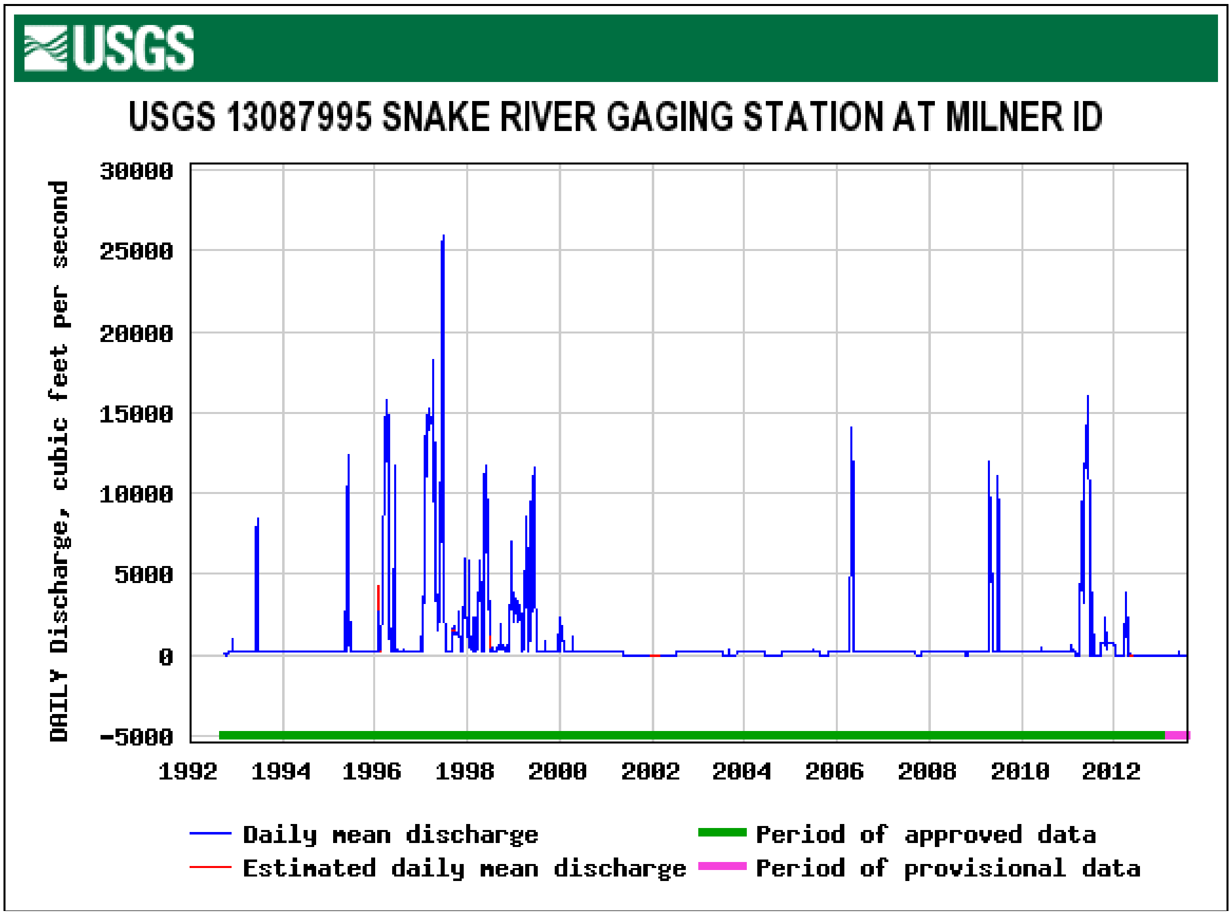

Figure 2: Snake River Flows at Milner Dam from 1992 (time of listing) through early 2013.

While water is diverted for agricultural purposes at C.J. Strike Dam, the primary reason for its operation is to provide hydroelectricity. It is unknown how much water is diverted for agriculture purposes at C.J. Strike Dam, however, under the current license requirements, discharge from this dam cannot drop below 110 cms (3,900 cfs), helping to ensure some minimal flows in the Snake River (USFWS 2004, p. 20). Given that information on the distribution and abundance of the Snake River physa downstream of C.J. Strike Dam is limited, it is difficult to assess the effects of these diversions at this dam on the species in this reach.

In summary, Snake River physa have been documented downstream of five dams on the Snake River, indicating that the species can exist to a certain extent with existing dams and their operations. Downstream of Minidoka Dam, the largest known Snake River physa population (along with most mollusk species) is found predominantly in habitat that is not seasonally dewatered. The relationship between the Snake River physa and other Snake River dams within its current known range is much less clear due to limited surveys and occurrence information, though existing information indicates that Snake River physa populations below the other dams are not as large or robust as the population downstream of Minidoka Dam. While hydroelectric operations may not be directly affecting the Snake River physa, their operations, in concert with other threats such as degraded water quality, likely limits the suitable habitat available to the species, especially where water levels can fluctuate substantially over short time periods (e.g. daily) from normal flows, or from the lack of flushing type flows during the summer months. Therefore we have determined operation of existing dams is a factor affecting the Snake River physa.

Degraded Water Quality

Factors that are known to degrade water quality in the Snake River include reduced water velocity, warming due to impoundments, and increases in the amounts of nutrients, sediment, and pollutants reaching the river (USFWS 2005, p. 114). Reduced flow/discharge increases water residence time in reservoirs, and allow for temperature increases in both reservoirs and in unimpounded reaches. These factors often lead to increases in primary productivity, phytoplankton levels, nutrient concentrations (FERC 2010, p. 35), and proliferation of algal and rooted macrophytes.

Several water quality assessments have been completed for the Snake River by the U.S. Environmental Protection Agency (USEPA), USBOR, U.S. Geological Survey (USGS), and IPC. All generally demonstrate that the water quality in the Snake River of southern Idaho is good for some months of the year (e.g. meeting Idaho's water quality criteria for the protection of aquatic life), but may be poor during summer high temperatures and low flows when water quality criteria such as dissolved oxygen may not be attained (Clark *et al.* 1998, p. 23; Clark and Ott 1996, p. 553; Clark 1997, pp. 8, 9, 19; Meitl 2002, pp. 32, 33; Clark *et al.* 2004, p. 38; Kosterman *et al.* 2008, p. 45). The Idaho River Ecological Assessment Framework (Grafe 2002, entire) and the Idaho Assessment of Ecological Condition [Rivers] (Kosterman *et al.* 2008, p. 45), document changes in the ecological condition[3] of the Snake River, with a decline in water quality and ecological condition from southeastern Idaho upstream of Heise (RKM 1370 (RM 851)) to southwestern Idaho near Weiser (RKM 565 (RM 351)).

In the Snake River downstream of Twin Falls, approximately 144 cms (5,100 cfs) of groundwater originating from the ESPA enters the Snake River, greatly increasing base flows (USEPA 2002, pp. 4-9) so that discharge at King Hill (RKM 882 (RM 548)) does not drop below 156 cms (5,500 cfs). These aquifer springs provide relatively clean and cool water that is also ideal for commercial trout production. This reach of the Snake River has numerous licensed aquaculture facilities responsible for approximately 76 percent of the commercial trout production in the U.S. (USEPA 2002, pp. 4-10). Several of these aquaculture operations also include fish-processing facilities and some of the processing wastes make their way into the Snake River, which include ammonia, bacteria, dead fish, fish feces, suspended sediments, and

[3] Ecological condition can be defined as "the state of the physical, chemical, and biological characteristics of the environment, and the processes and interactions that connect them" (U.S. Environmental Protection Agency (USEPA) 2008, p. 6-3).

residual quantities of drugs and chemicals used to control disease outbreaks (USEPA 2002; pp. 4-20). Falter and Hinson (2003, pp. 26, 27) reported "significantly higher concentrations" (i.e. elevated, not increasing) of nitrogen and phosphorous, as well as higher levels of trace elements including zinc, copper, cadmium, lead, and chromium in sediments downstream of aquaculture facilities when compared to areas upstream of those facilities. The impact of these effluents and trace elements to the growth, survival, and reproduction of Snake River physa is unknown, but recent studies have shown another native Snake River species, the Jackson Lake springsnail (*Pyrgulopsis robusta*) is highly sensitive to copper (a common component in algaecides), and pentachlorophenol, a restricted-use pesticide/wood preservative (Ingersoll 2006, p. 3). Both aquaculture facilities and irrigation conveyances typically require the periodic use of algaecides to keep facilities and canals free of filamentous algal growth. Some of these compounds contain copper and are known to be highly toxic to snails, and may also affect diatoms (unicellular algae), the likely primary food source for Snake River physa. Lastly, benthic macroinvertebrate densities and biomass in Snake River studies have been shown to generally increase downstream of aquaculture discharges with a concomitant decrease in species richness, indicating an overall decline in habitat quality immediately downstream of aquaculture facilities (Falter and Hinson 2003, p. 13).

Over 23,310 square kilometers (km^2) (9,000 square miles (mi^2)) of irrigated land are located within the Snake River drainage or that of its tributaries (Johnson *et al.* 2013, *in litt.*). Most of the crops grown in this area are subject to modern agricultural practices which include the use of herbicides, insecticides, fungicides, and fertilizers (which may include copper); a proportion of which make their way into the Snake River via irrigation return flows and through ground water recharge (Clark *et al.* 1998, p. 2).

Cattle production and confinement has increased substantially in south central Idaho within the range of the Snake River physa (Cassia, Gooding, Jerome, Minidoka, and Twin Falls Counties). From 1992 through 2012, total cattle numbers in these counties increased by over 100 percent, from an estimated 467,500 to 946,500 head (both dairy and beef combined; USDA 2013, *in litt.*). Wastewater from confined animal feeding operations has been identified as a major contributor to water quality degradation in surface waters, groundwater, and springs in southern Idaho (Clark *et al.* 1998, p. 19; Bahr and Carlson 2000, p. 2; Schorzman *et al.* 2009, p. 19). Nitrate values from monitored wells in southern Idaho between 1990 and 2003 indicate an increasing trend in concentrations overall, although there were decreases at some wells (Neely 2005, pp. 5-11). Clark *et al.* (1998, p. 3) report that 10 percent of the wells sampled between Burley and Hagerman contained nitrate concentrations in excess of 10 mg/L, quantities regarded as harmful to human health.

Several other environmental pollutants have been documented in the Snake River within the range of Snake River physa. Water samples collected at locations in the middle and upper Snake River including Box Canyon (RKM 946 (RM 588)), between 1989 and 2000, had concentrations of cadmium and lead exceeding the State of Idaho's acute or chronic criteria (Hardy *et al.* 2005, pp. 17, 64, 65). Research at Montana State University revealed concentrations of lead, cadmium, and arsenic in the tissues of native Snake River snails (Richards. 2002, *in litt.*), but observations of effects from these concentrations were not reported. In additional studies, Rattray and others detected trace elements including barium, chromium, lithium, manganese, and zinc in water samples that supply the major springs on the north side of the Snake River (Rattray *et al.* 2005, pp. 7, 8). While many of these pollutants are present in relatively low concentrations throughout the species' range, and in some locations exceed EPA aquatic life standards, the effect of most of these pollutants on Snake River physa is unknown.

The human population has also grown within southern Idaho. For example, from 2000 through 2011, the human population in Cassia, Gooding, Jerome, Minidoka, and Twin Falls Counties in southern Idaho grew 15 percent (U.S. Census Bureau 2013, *in litt.*), with the city of Twin Falls growing by 20 percent from 2000 to 2010 (City of Twin Falls Data 2013, *in litt.*). Sewage treatment facilities from these municipalities have permitted National Pollutant Discharge Elimination System (NPDES) discharges of nutrients, ammonia, suspended solids, organic matter, and industrial wastes into the Snake River (Clark *et al.* 1998, p. 7; USEPA 2002, pp. 4-19). Other nonpoint discharges from urban areas, such as parking lot run-off and urban-use pesticides (Clark *et al.* 1998, p. 7), do not undergo treatment but can be reasonably expected to make their way into the Snake River and/or its tributaries. Although urban run-off likely contributes to declines in water quality in the Snake River, it is not considered to be a major source of pollutants (Clark *et al.* 1998, p. 19).

One avenue to assess recent trends of water quality throughout the range of the Snake River physa is through evaluation of existing nutrient and contaminant loads through the Total Maximum Daily Load (TMDL) monitoring program (see Section 2.3.2.4 - Inadequacy of Existing Regulatory Mechanisms for detailed information regarding TMDLs). The Snake River downstream of Minidoka Dam (the uppermost range of the Snake River physa and site of the most robust known population) to Milner Dam was listed as not meeting the State's criteria for sediment, dissolved oxygen, total phosphorus (TP; a nutrient source for macrophyte growth), and oil and grease (IDEQ 2000, p. 46). Two of these, total suspended solids (TSS) and TP, were found at higher concentrations with increasing proximity to Milner Reservoir relative to concentrations further upstream at Minidoka Dam, likely due to the result of numerous drains and tributaries that empty into the Snake River as one moves downstream (IDEQ 2000, pp. 64-65). The recent 5-year review for the TMDL indicates that this stretch of the Snake River continues to be listed as not supporting water quality standards for TP, and may not be supporting TSS, though additional data is needed. TP values are actually higher than those recorded before the TMDL was established (IDEQ 2012, pp. 26 and 72), indicating that water quality may further be deteriorating since the TMDL was established.

In 2010, the 5-year review was completed for the TMDL for the Middle Snake River Watershed Management Plan (1997), Upper Snake Rock Watershed Management Plan (2000), and the Upper Snake Rock Modification (2005; IDEQ 2010, entire). This review covers the section of the Snake River and certain tributary segments from near Milner Dam (RKM 1027.6 (RM 638.5)) at Murtaugh, Idaho to King Hill, Idaho (RKM 877.1 (RM 545.0); IDEQ 2010, p. xii), where the primary pollutants of concern are TSS and TP (IDEQ 2010, p. xi). Although this section is the species type locality, more recent surveys have been unsuccessful in locating the species in this section of the Snake River. Generally, water quality has improved in this section of the Snake River (Buhidar 2006, *in litt.*; IDEQ 2010, p. xiii) although TP is still elevated (IDEQ 2010, pp. 7, 36).

The Mid Snake River/ Succor Creek Subbasin TMDL implementation plan was completed in July of 2005, with the latest 5-year review completed in September, 2011 (IDEQ 2011). This TMDL encompasses a large portion of southwest Idaho, and includes the Snake River between Swan Falls Dam (RKM 736.6 (RM 457.7)) and the Oregon State line (RKM 654.2 (RM 406.5)). Previously (1995-2003), this section of the Snake River yielded collections of Snake River physa (IPC 2012, *in litt.*). The 5-year review for this TMDL indicates water quality is declining, with sediment, temperature, bacteria, and phosphorus the main sources of pollution (IDEQ 2011, p. v). Total Phosphorous (the only pollutant in the Snake River with an allocation in this TMDL) levels within this Snake River subbasin appear to have increased and are above criteria, although the trend is not clear (IDEQ 2011, p. 31).

Downstream of Minidoka Dam, the river reach containing the most robust and stable known population of Snake River physa in the Snake River, is still experiencing higher pollutant levels such as TP and potentially TSS due to numerous drains and tributaries entering the Snake River. What likely counteracts the degraded water quality conditions downstream of the Minidoka Dam is that flushing flows are higher during the summer and early autumn months, likely keeping the pebble and gravel beds free of fine sediments and macrophytes during the period of highest insolation and summer temperatures. As stated in Section 2.3.1.6, Snake River physa have been collected with less sampling effort within the Minidoka reach versus the Lower Salmon Falls Dam to Ontario, Oregon reach, indicating the species is less abundant outside the Minidoka reach. This is likely due to various reasons, including suitable habitat availability, water quality deterioration, and altered flow regimes (for example, flows are maintained at higher rates, and for longer periods, during summer downstream of Minidoka Dam, while the inverse is true downstream of Swan Falls Dam).

In summary, surface water quality in the Snake River has been impacted by the cumulative effects of decades of agricultural, municipal, and industrial activities within the watershed, and by the regulation of flows. As discussed above in Section 2.3.1 Biology and Habitat, the current ranges of water temperatures in the Snake River do not seem to limit Snake River physa; the species appears to tolerate the range of temperatures observed. However, additional factors such as sediments or suspended solids introduced into the Snake River from livestock use, agricultural run-off, fish production wastes, and other land uses (Bowler *et al.* 1992, p. 45; Hardy *et al.* 2005, p. 7), are likely filling the interstitial spaces between bed substrates and providing an environment favorable for macrophyte growth in the river. However, while degraded water quality (primarily due to increased sediment and nutrients) does not currently appear to be negatively affecting Snake River physa habitat uniformly across its range, it likely reduces available suitable habitat (i.e. relatively clean gravel to pebble, and possibly gravel to cobble with limited fines and macrophytes) in several Snake River reaches outside of the Minidoka reach, within the range of the species. Therefore, we have determined degraded water quality is a threat factor which is modifying or curtailing the Snake River physa's habitat or range.

<u>Ground Water Withdrawals</u>

Over a 95-year period of recordkeeping, spring flows from the ESPA contributed between 30-85 percent of flow in the Snake River at King Hill (Richards *et al.* 2006, pp. 84, 85). Prior to the 1950's, irrigation water was moved from rivers and streams with the use of surface conveyance canals. Seepage from these canals into the fractured basalt resulted in recharge of the ESPA and corresponding increases in spring discharge (Kjelstrom 1992, entire). Based on analyses reported by Richards and others (2006, p. 84), and Ondrechen (2004, *in litt.*), spring discharges in the early 2000's may have been 15 percent greater than they were in the early 1900's, however, spring discharges began a sharp decline with the increased use of groundwater for irrigation, and a corresponding decrease in flood irrigation due to the use of central pivot sprinklers, which contribute little to groundwater recharge (Ondrechen 2004, *in litt.*; University of Idaho 2007, *in litt.*). Current estimates of groundwater use for Idaho are > 34 billion liters (9 billion gallons) per day, with agricultural uses accounting for about 60 percent of this total (IDEQ 2013a, *in litt.*). These large withdrawls have been documented to be contributing to the depletion of the overall ground water storage in the ESPA (University of Idaho 2007, *in litt.*). Springs flows from the ESPA provide an important contribution in maintaining/improving water quantity and quality in the Snake River within the range of the Snake River physa; however, the point at which reduced spring discharge will have adverse effects on the species cannot be predicted.

<u>Climate Change</u>

Air temperatures have been warming more rapidly over the Rocky Mountain West compared to other areas of the coterminous U.S. (Rieman and Isaak 2010, p. 3). Data from stream flow gauges in the Snake River watershed in western Wyoming, and southeast and southwest Idaho indicate that spring runoff is occurring between 1 to 3 weeks earlier compared to the early twentieth century (Rieman and Isaak 2010, p. 7). These changes in flow have been attributed to interactions between increasing temperatures (earlier spring snowmelt) and decreasing precipitation (declining snowpack). Global Climate Models project air temperatures in the western U.S. to further increase by 1 to 3 °C (1.8 to 5.4 °F) by mid-twenty-first century (Rieman and Isaak 2010, p. 5), and predict significant decreases in precipitation for the interior west. Areas in central and southern Idaho within the Snake River watershed are projected to experience moderate to extreme drought in the future (Rieman and Isaak 2010, p. 5).

As discussed earlier, Snake River physa appear to tolerate a range of water temperatures in the Snake River. If Snake River water temperatures rise as a result of climate change, indirect impacts to the species may occur, including effects on metabolic processes, foraging behavior, and dynamics with predators and/or invasive species (Poff *et al.* 2002, entire; Williamson *et al.* 2008, p. 248; and Rahel and Olden 2008, entire). In addition, indirect impacts of climate change include the possible synergy of higher temperatures with contaminants (Sokolova and Lannig 2008, p. 183), the increased incidence of cyanobacteria (i.e. blue green algae) blooms due to higher temperatures, higher atmospheric carbon dioxide, and increased nutrient enrichment (Paerl and Huisman 2008, entire; Paerl *et al.* 2011, p. 1743). Further, habitats supporting Snake River physa could be reduced due to low summer flows and warmer temperatures leading to an extended growing season for macrophytes.

The vulnerability to climate change are projected to be highest in river basins with the largest hydrologic response to warming and lowest management flexibility – that is, fully allocated, mid-elevation, temperature-sensitive, mixed rain-snow watersheds with existing water conflicts among users of summer water, such as the Snake River basin (National Climate Assessment and

Development Advisory Committee 2013, p. 726). The Snake River is a highly regulated river system that serves multiple uses, including, but not limited to, irrigation, hydropower, and aquaculture. Even though the Snake River is a highly managed riverine system, if precipitation decreases within the Snake River basin, as the models and literature forecast, and groundwater flows decline due to continued depletion of the aquifer, there may be less water within the river itself, especially as competition for this limited resource increases (Meyer *et al.* 1999, p. 1373). With these changes, we anticipate suitable habitat for the Snake River physa will become limited and this species will further contract its range. Therefore we have determined future projected climate change effects are a factor affecting the habitats and range of the Snake River physa.

Summary of present or threatened destruction, modification or curtailment of its habitat or range:

The factors affecting the existing and potential habitat of Snake River physa are numerous, complex, and inter-related. The Snake River is often regarded and treated as a "working river" (IWRB 2012, p. 42), upon which a substantial proportion of southern Idaho's economy is reliant. Currently, no segments of the Snake River within the range of the Snake River physa are protected from development. Operation of existing dams, degraded water quality, and climate change have the potential to reduce the amount of water and/or flow in the Snake River and further degrade the quality of that water. These threats also reduce available habitat due to increased sedimentation, substrate embeddedness, and macrophyte growth. In addition, current models of future climate change indicate reduced snow pack and increasing incidence of drought. Combined with the probable continued growth in both population and agriculture within this region in concert with the forecasted effects of climate change, the demand on water resources in Southern Idaho will likely increase in the future and suitable habitat conditions within the range of the Snake River physa will decline over time. Therefore, the present or threatened destruction, modification or curtailment of its habitat or range remains a factor that adversely affects the Snake River physa.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Based on the best available scientific and commercial information, the overutilization for commercial, recreational, scientific or educational purposes is not an extinction factor affecting the Snake River physa, and is not likely to result in the endangerment or extinction of the species in the foreseeable future. There is no known commercial or recreational use of the species and collections for scientific or educational purposes are limited in scope and extent. While collection could result in mortality of individuals, these collections are regulated by permits issued by the Service, and are unlikely to have a population level effect since relatively few persons and/or institutions have requested to collect specimens of Snake River physa, and the number of individuals is limited within the species range.

2.3.2.3 Disease or predation:

Parasitic trematodes similar to those of the genus *Microphallus* have been identified in some freshwater snails in Idaho (*e.g., Pyrgulopsis robusta*); however, the occurrence of trematode parasites in Snake River physa has not been studied (Dybdahl *et al.* 2005, p. 8). Predation on aquatic snails by crayfish and fish is well documented (Lodge *et al.* 1994, p. 1265; Martin *et al.* 1992, p. 476; Merrick *et al.* 1992, p. 225; Lodge *et al.* 1998, p. 53). Predators of the Snake River physa have not been documented, but we assume that some predation by both native and nonnative aquatic and terrestrial species occurs. Based on the best available scientific and commercial information, disease or predation is not currently a factor threatening the viability of the Snake River physa and is not expected to become one in the foreseeable future.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

In the 1992 final listing rule (57 FR 59253), we found inadequate regulatory mechanisms to be a threat to the Snake River physa because: (1) Regulations were inadequate to curb further water withdrawal from ground water spring outflows or tributary spring streams; (2) it was unlikely that pollution control regulations would reverse the trend in nutrient loading in the near future; (3) there was a lack of State-mandated protections for invertebrate species in Idaho; and (4) regulations did not require FERC or the U.S. Army Corps of Engineers to address Service concerns regarding licensing hydroelectric projects or permitting projects under the Clean Water Act (CWA) for unlisted snails. Below we have updated the analysis of threats under inadequacy of existing regulatory mechanisms.

<u>Surface and Ground Water Management</u>

The Idaho Department of Water Resources (IDWR) manages water in the State of Idaho. Among the IDWR's responsibilities is the development of the State Water Plan (Water Plan) (IWRB 2012, entire). The Water Plan outlines objectives for the conservation, development, management, and optimum use of all unappropriated waters in the State. One of these objectives is to ''maintain, and where possible enhance water quality and water-related habitats'' (IWRB 2012, p. 6). It is the intent of the Water Plan that any water savings realized by conservation or improved efficiencies is appropriated to other beneficial uses (*e.g.,* agriculture, hydropower, or fish and wildlife).

The Water Plan also states that the capacity of water storage, flood control, and flow regulation on the Snake River is insufficient for future beneficial uses (IWRB 2012, p. 55) and further states that construction of new reservoirs, enlargement of existing reservoirs, and development of off-stream storage sites may be necessary to meet future demands (IWRB 2012, p. 19). Given the non-protected status of the river reach that constitutes the range of the Snake River physa (see Factor A - Section 2.3.2.1), there exists no assurances that future development of water resource projects will not negatively impact habitat or water quality upon which the species depends.

The ESPA discharges approximately 144 cms (5,100 cfs) of groundwater to the Snake River in the Thousand Springs area (approximately RKM 940-982 (RM 584-610)), greatly increasing the

Snake River's base flows (USEPA 2002, pp. 4-9). The storage in the ESPA has been declining since the 1950's due to several reasons, including more efficient water delivery through canals (thus decreasing seepage into the ground), increased groundwater pumping, drought, and climate change (IWRB 2013, p. 2). This has resulted in declines in the average spring outflows in the Thousand Springs area over the past 50 years (Clark and Ott 1996, pp. 553-555). While the Snake River physa is found within the Snake River itself, it has not been found in areas where springs enter the Snake River.

The IDWR and other State agencies have created additional regulatory mechanisms that limit future surface and ground water development in the ESPA, including the continuation of various moratoria on new consumptive water rights, and the designation of Water Management Districts (Caswell 2007, *in litt.*). The State is attempting to stabilize aquifer levels and enhance cold water spring outflows from the ESPA by implementing water conservation measures identified in the Comprehensive Aquifer Management Plan (CAMP) for this area (IWRB 2010, entire). The long-term objective of the CAMP is to incrementally achieve a net ESPA water budget of 600,000 acre feet annually by the year 2030 through a mix of management strategies, including aquifer recharge, ground-to-surface water conversions, demand reduction strategies, and weather modification (IWRB 2013, p. 3).

While aquifer recharge may reduce the rate of groundwater depletion in the ESPA, it also may affect ESPA groundwater quality if measures are not taken to ensure water utilized for recharge purposes is relatively clean. As stated above, the Snake River physa is found within the Snake River itself and has not been found in areas where springs enter the Snake River. Therefore, it is difficult to assess possible impacts to the Snake River physa if groundwater quality is affected by aquifer recharge activities. Overall though, since adoption of the CAMP, progress is being made towards strategy implementation (IWRB 2013, p. 3), although it is too early to determine if these strategies are effective at reducing the rate of groundwater depletion in the ESPA.

In summary, there are no assurances that current State regulations and policies will protect the Snake River physa and its habitat from water projects that occur in the Snake River and the ESPA. While there are no known water development projects within the range of the Snake River physa, future development projects would be a concern if they impacted the remaining free-flowing reaches of the Snake River within the species' range. Conservation measures in the ESPA CAMP have been developed and implemented, but it is too early to determine if they can stabilize ESPA water levels and its discharges into the Snake River. While we anticipate ground water levels in the ESPA will continue to decline even if water conservation measures are implemented, the Snake River also receives substantial amounts of water from areas outside of the ESPA. Given this complexity, we cannot predict when, or if spring flows into the Snake River will be a factor impacting the Snake River physa or its habitat.

Pollution Control Regulations

Various State-managed water quality programs are being implemented within the range of the Snake River physa. These programs are tiered off the CWA, which requires States to establish water-quality standards that provide for (1) the protection and propagation of fish, shellfish, and wildlife, and (2) recreation in and on the water. As required by the CWA, Idaho has established water-quality standards (*e.g.,* for water temperature and dissolved oxygen) for the protection of cold-water biota (*e.g., salmonids,*) in many reaches of the Snake River. The CWA also specifies that States must include an antidegradation policy in their water quality regulations that protects water-body uses and high quality waters. Idaho's antidegradation policy, updated in the State's 1993 triennial review, is detailed in their Water Quality Standards (IDEQ NA, pp. 15-16).

While point source pollution regulations are enforceable through the CWA, nonpoint source water pollution is primarily addressed through non-regulatory means under the CWA (USEPA 2013a, *in litt.*). The IDEQ works closely with the USEPA to manage point and non-point sources of pollution to water bodies of the State through the National Pollutant Discharge Elimination System (NPDES) program under the CWA. IDEQ has not requested the authority from the USEPA to issue NPDES permits, and therefore all NPDES permits within the State of Idaho are issued by the USEPA Region 10 (USEPA 2013b, *in litt.*). These NPDES permits are written to meet all applicable water-quality standards established for a water body to protect human health and aquatic life.

One statewide NPDES permit developed by EPA for activities capable of discharging waste on a relatively large basis within the range of the Snake River physa is for the numerous aquaculture facilities located on tributaries and springs that flow into the Snake River (USEPA 2007 entire; Helder 2013, *in litt.*). In Idaho, there are approximately 115 permitted aquaculture facilities, 70 percent of which operate in the Magic Valley, discharging into the Snake River or its tributaries within the range of the Snake River physa (IDEQ 2013b, *in litt.*). Aquaculture facilities that produce less than 9,072 kilograms (20,000 pounds) of fish annually are not required to obtain an NPDES permit (USEPA 2007, p. 9). These smaller facilities lie outside of this regulatory nexus, and as such their discharges are not regulated. The Service is unaware how many unpermitted aquaculture facilities discharge to the Snake River or its tributaries within the range of the Snake River physa.

Under Section 303(d) of the 1972 Clean Water Act, States are required to develop lists of impaired waters not meeting State water quality standards (USEPA 2013c, *in litt.*). Waters that do not meet water-quality standards due to point and non-point sources of pollution are listed on USEPA's 303(d) list of impaired water bodies. IDEQ, under authority of the State Nutrient Management Act, is coordinating efforts to identify and quantify contributing sources of pollutants (including nutrient and sediment loading) to the Snake River basin via the TMDL approach. In water bodies that are currently not meeting water quality standards, the TMDL approach applies pollution-control strategies through several of the following programs: State Agricultural Water Quality Program, Clean Water Act section 401 Certification, USBLM Resource Management plans, the State Water Plan, and local ordinances. Several TMDLs have been approved by the USEPA in Snake River stream segments within the range of the Snake River physa (Buhidar 2006, *in litt.*), and most apply to TSS, TP, or temperature.

Within the range of the Snake River physa in the Snake River, there are 4 TMDLs approved by the USEPA since the Snake River physa was listed: 1) Snake River-King Hill-C.J. Strike Reservoir Subbasin, 2) Snake River (Middle)-Succor Creek Subbasin, 3) Snake River (Middle)-Upper Snake Rock Subbasin, and 4) Snake River (Middle) Subbasin. Status reviews of these TMDLs indicate mixed success, with certain areas of the Snake River showing improving water quality, while other areas are decreasing in quality. Overall, the majority of the stream segments within the range of Snake River physa habitat with existing TMDLs are not meeting the water quality standards established by the TMDL for one or more pollutants, particularly TSS and TP.

In summary, within the State of Idaho, point-source discharges are regulated through the NPDES permitting process, while non-point source discharges are addressed through TMDLs using waste load calculations for that waterbody; however, there is no implementation authority for the non-point discharges. Some stream segments within the range of the Snake River physa and under existing TMDLs are not meeting water quality standards for one or more pollutants. Although regulatory pollution control methods authorized under the CWA have been implemented within the range of the Snake River physa, water quality remains degraded, with no indication that it will improve in the near future. Therefore, the inadequacy of existing regulatory mechanisms regarding Federal and State pollution control regulations continues to be a factor affecting the Snake River physa.

State Invertebrate Species Regulations

There has been no change in State regulations regarding the protection of invertebrates since the time of the 1992 listing. The IDFG, under Idaho Code section 36-103, is mandated to preserve, protect, perpetuate, and manage all wildlife. However, these regulations do not extend protection to invertebrate species. The only regulations provided for Snake River physa are provided by the Endangered Species Act. In 2005, Idaho finalized the State's Comprehensive Wildlife Conservation Strategy (CWCS; IDFG 2005, entire), which is a conservation strategy for the State's species of greatest conservation need (SGCN). As part of the CWCS, the Snake River physa is included in the State's list of SGCN (IDFG 2005, pp. 423-425), though there is no regulatory authority associated with this designation. In summary, there are no State regulations in place that are specific to the Snake River physa; therefore State invertebrate species regulations for the Snake River physa continue to be inadequate.

Federal Consultation Regulations

Since the species was listed in 1992, Federal agencies, including the Army Corps of Engineers, FERC, and the USBOR, have been required to comply with section 7 of the Act on any projects or managed activities that may affect the Snake River physa. If the species is delisted, terms and conditions now required of these agencies and their applicants to reduce the effects of their actions on the Snake River physa, such as placing conservation measures into agency permits, would not be required.

From 2006 to 2008, the USBOR contracted with Montana State University to survey the Snake River downstream of Minidoka Dam to determine if any Snake River physa populations or colonies existed, and if found, to determine through genetic analysis if the Snake River physa is a distinct species (Gates and Kerans 2010, entire). This work resulted from a 2005 section 7, formal consultation between the Service and USBOR for continued operation and maintenance of 12 USBOR dams in the Snake River basin above Brownlee Reservoir (approximately RKM 515 (RM 320)) (USFWS 2005, p. 1). Gates and Kerans' work was successful in finding the species present within this reach which led to a much greater understanding of their habitat use.

Their research also confirmed through genetic analysis that the Snake River physa is a valid species (2010, p. 5; Gates *et al.* 2013, pp. 164-168).

As part of the 2005 section 7 formal consultation with the USBOR, a 11.2 cms (400 cfs) year-round minimum outflow below Minidoka Dam would be maintained for 30 years from 2005 (USFWS 2005, p. 27). As stated in section 2.3.2.1 (Present or threatened destruction, modification or curtailment of its habitat or range, Operation of Existing Dams), if this minimum flow requirement was removed, and flows during winter fell below this minimum, additional portions of the riverbed would be exposed to freezing temperatures, further impacting Snake River phsya and its habitat. Therefore this minimum flow is important for maintaining existing habitat conditions for the most robust known population of Snake River physa.

In 2012, the USBOR initiated a 5-year monitoring effort downstream of Minidoka Dam at two locations to assess the effects of the Minidoka Dam spillway replacement on a population of Snake River physa that inhabit the pool area directly downstream of the spillway. The locations being monitored include a population further downstream at Jackson Bridge (RKM 1077 (RM 669)), along with the population directly downstream of the spillway (RKM 1085.5 (RM 674.5)) (USBOR 2013, entire). The first year of this monitoring effort started in August of 2012, and 45 live Snake River physa were collected at the Jackson Bridge site (all from within the permanently-wetted channel), while no individuals were collected in the pool area directly downstream of the spillway (USBOR 2013, pp. 18-20). It is anticipated that this effort will continue through 2016.

As part of the relicensing for the Swan Falls Hydroelectric Project, IPC and the Service are cooperating on developing and implementing a Snake River physa protection plan required by the FERC in their 2012 license for the Swan Falls Hydroelectric Project (FERC 2012, entire). This protection plan is designed to assess the potential effects of the IPC's operations downstream of Swan Falls Dam, and was approved as part of section 7 consultation between the Service and IPC and license issuance (FERC 2012, pp. 10-11). This protection plan will target previously identified Snake River physa locations from Swan Falls Reservoir (RKM 755.4 (RM 469.4)) downstream to Marsing, Idaho (RKM 682 (RM 424), USFWS 2012a, p. 47; FERC 2012, p. 7). If Snake River physa are found on a relatively consistent basis, a regular monitoring system to track population trends will be implemented. This effort may provide additional information on distribution, abundance, and habitat use in an area of their range where our understanding of the species is limited. These studies and their analyses are scheduled to be initiated in 2014.

Since the Snake River physa was listed as endangered under the Act in 1992, Federal agencies have been required to consult on their activities that may impact the Snake River physa or its habitat, therefore, the inadequacy of existing regulations under section 7 of the Act regarding federal consultation is not currently a threat. In addition, section 7 consultation requirements have benefited the Snake River physa from surveys and studies that have been initiated as an outcome of consultation, and have provided additional knowledge, such as the species' biological requirements, known range, and species validity.

Invasive Species Regulations

Numerous authorities and regulations are utilized to manage existing populations of invasive species, and seek to prevent introduction and establishment of new species and populations. Regulation of invasive species management in Idaho falls under multiple State laws, including; 22-1900, Invasive Species Act; Idaho Rule 02.06.09, Rules Governing Invasive Species; 22-2012, 22-2016 Plant Pest Act; 22-2409, Noxious Weed Law; 36-104, 36-106, 36-1102; 13.01.10. Fish and Game Authorities; IDAPA 13.01.03, Public Use of Land Owned or Controlled by Idaho Department of Fish and Game; 25-214, Disease Inspection and Suppression; 25-3900, Deleterious Animals; 38-602, Forest Pests (Idaho State Department of Agriculture (ISDA) 2012, p. 32). Various Federal authorities exist that address invasive species issues, including, but not limited to; the Lacey Act; the Nonindigenous Aquatic Nuisance Prevention and Control Act; and the National Invasive Species Act (Idaho Invasive Species Council (IISC) 2012, p. 33).

For aquatic nuisance species, Idaho developed the Idaho Aquatic Nuisance Species Plan, a supplement to Idaho's Strategic Action Plan for Invasive Species (IISC 2007, entire; IISC 2012, entire). In 2009, the Idaho Legislature enacted the Invasive Species Prevention Sticker Rules (IDAPA 26.01.34), which require owners of motorized and non-motorized boats to purchase and have an Invasive Species Sticker on their boats to launch and operate on Idaho's waters (IISC 2012, p. 8). Concurrent with passage of the Invasive Species Prevention Stickers, the ISDA, along with other local governments have initiated mandatory inspection and decontamination stations at various major highway entrances throughout the State to reduce the spread of aquatic invasive species into Idaho (ISDA 2012, pp. 5-7). Since 2009, these stations have operated every year during the boating season and have resulted in the inspection of over 154,000 watercraft, with 93 boats being identified as potentially harboring the invasive zebra (Zebra (*Dreissena polymorpha*) and/or Quagga mussels (*Dreissena rostriformis*) (ISDA 2012, p. 1). These two species have not been found in Idaho but are known to severely impact aquatic habitats when they become established. While it is unknown how many boats with these species and other invasive species may have come into the State undetected, this program has been effective at stopping a number of contaminated boats from potentially entering the Snake River within the range of the Snake River physa.

The State of Idaho and the Federal Government have implemented various measures for stopping and controlling the spread of invasive species that may affect the Snake River physa or its habitat. One measure, mandatory State boat inspection stations, has had some level of success at containing the introduction of invasive species into Idaho's waters, though it is unknown how many fouled boats are not being stopped by these inspection stations. Until additional action is taken to reduce the incidences of fouled-boats leaving contaminated waters, there will be a continued threat of new invasive species becoming established within Idaho, even given the continued operation of the mandatory boat inspection stations within the State.

Summary of Inadequacy of existing regulatory mechanisms: Depletion of cold water spring flows and declining ground water levels are a collective result of drought and changing climatic conditions, changes in irrigation practices, and ground water pumping for agriculture and other purposes. We anticipate ground water levels, and subsequent spring flow output will likely continue to decline even if water conservation measures are developed and implemented. This threat is not directly affecting the species at this time since the Snake River physa is known to primarily occur in deeper, flowing water habitats within the Snake River. However, as surface water flows decline due to climate change, and groundwater levels decline, this threat could become more pronounced.

Point and non-point discharges are regulated in Idaho through the NPDES and TMDL programs of the CWA, and apply to habitats occupied by the Snake River physa. While water quality in some stretches of the Snake River has improved, primarily for TP and TSS, in other stretches it has continued to decline. Water quality that is not meeting standards continues to be a factor impacting Snake River physa habitat, as well as the ability to regulate or manage pollutants entering the Snake River through various sources, both point and non-point (including through the groundwater). There continues to be no specific State regulations protecting the Snake River physa or other listed snails. Some conservation benefits to the species are being realized through section 7 consultation with other Federal agencies, but without the Act's protection there are no regulatory assurances that these conservation benefits would continue. Invasive species regulations have been implemented at both the Federal and State level. While Idaho's regulations are actively trying to keep new aquatic invasive species out of Idaho's waters, the lack or inadequacy of existing regulations regarding boats from aquatic invasive species source waters is increasing the threat of these species becoming established in Idaho, and potentially within the range of the Snake River physa. Based on this information, the inadequacy of existing regulatory mechanisms continues to be a threat to the Snake River physa.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

At the time of listing, the threats to Snake River physa associated with other natural or manmade factors affecting its continued existence were competition with the non-native New Zealand mudsnail (*Potamopyrgus antipodarum*; 57 FR 59254). Below we have addressed an updated analysis of threats under other natural or manmade factors affecting its continued existence.

<u>New Zealand Mudsnail Competition and Aquatic Invasive Species</u>

The 1992 listing rule stated that New Zealand mudsnails did compete for habitat with the Snake River physa in the mainstem Snake River (57 FR 59254). The New Zealand mudsnail appears to flourish in Snake River reaches under a variety of environmental conditions, including low dissolved oxygen and on substrates of mud or silt, but it is also found at high densities in some cold-water spring tributaries to the Snake River (e.g. up to 500,000 snails/m^2 (46,500/ ft^2) at Banbury Springs; Richards *et al.* 2001, p. 375). New Zealand mudsnails have been documented in dark mats at densities of nearly 0.62/ mm^2 (400 individuals/ in^2) in free-flowing habitats within the range of the Snake River physa (57 FR 59254). Although the New Zealand mudsnail can tolerate various water velocities, they appear to reach their highest densities in slower moving waters (Richards *et al.* 2001, pp. 378, 389).

Some researchers have suggested that the New Zealand mudsnail competes with native species for food and/or space (Kerans *et al.* 2005, pp. 135, 136; Hinson 2006, p. 41) and can dominate ecosystem nutrient and energy flow (Hall *et al.* 2003, p. 411). Research has shown that New Zealand mudsnails influence the growth of sympatric freshwater snails (Richards 2004, entire) and can displace native species (Hall *et al.* 2006, entire). Competition from the New Zealand mudsnail was shown to negatively impact growth rates of the Bliss Rapids snail (*Taylorconcha serpenticola*), also a listed species endemic to the Snake River drainage, under experimental conditions (Richards 2004, pp. 117-118). In enclosure experiments, increasing New Zealand mudsnail densities also resulted in lower Bliss Rapids snail densities (Richards 2004, pp. 117-118).

The New Zealand mudsnail was collected by Gates and Kerans (2010, p. 25) in the Minidoka reach in approximately the same numbers as the Snake River physa (total abundance of 294 and 271 respectively), but whether the Snake River physa and New Zealand mudsnail compete for the same resources has not been assessed. This reach of the Snake River is free flowing and doesn't contain the optimum habitat for New Zealand mudsnails which are found in slower moving water. Considering that the two species were found in about the same numbers where Snake River physa was most abundant may suggest that under what are assumed to be optimum habitat conditions for Snake River physa (in the Minidoka reach), competition from New Zealand mudsnail appears to be minimal. In areas supporting high numbers of New Zealand mudsnail that overlap with Snake River physa habitat, it is possible that the New Zealand mudsnail could have a competitive edge over Snake River physa. However, at this time we don't have the information that New Zealand mudsnails are impacting, or are an overall threat to Snake River physa. It is likely additional aquatic invasive species will colonize or occur within the range of the Snake River physa, (see Section 2.3.2.4 - Inadequacy of existing regulatory mechanisms – Invasive Species Regulations), but the effects they will have on Snake River physa are unknown at this time.

Small population size, habitat fragmentation, and loss of connectivity

The two general areas of the Snake River where Snake River physa have been found since the time of listing are downstream of Minidoka Dam (RKM 1086-1067.8 (RM 675-663.5)) and downstream of Lower Salmon Falls Dam (RKM 922 (RM 573)) to Ontario, Oregon (RKM 592 (RM 368)). The largest known population is found within the 18.5 RKM (11.5 RM) reach of river directly downstream of Minidoka Dam to the beginning of the reservoir pool at Milner Dam. At certain times of the year, the entire flow of the Snake River is diverted at Milner Dam to provide water for irrigation. This leaves the river essentially dry for approximately 2.6 km (1.6 mi) downstream of Milner Dam. This is important to note because the next known occurrence of Snake River physa is downstream of Lower Salmon Falls Dam (RKM 922 (RM 573)). While the Minidoka reach population is relatively robust, the entire flow of the Snake River is essentially severed as a source for downstream populations when Milner Dam is diverting the entire flow of the Snake River. While there have been reports of Snake River physa occurring upstream of Minidoka Dam (Pentec 1991, *in litt.*), these reports have not been confirmed. Therefore, the Minidoka reach population is regarded as isolated, with limited possibility for dispersal into, or out of the population.

Further downstream, from C.J. Strike Reservoir (RKM 789 (RM 490)) downstream to Ontario, Oregon (RKM 592 (RM 368)), the Snake River physa is patchily distributed. Unlike the

Minidoka reach where the population is relatively robust, this area has had very limited collections of Snake River physa (Keebaugh 2009). Currently, C.J. Strike and Swan Falls dams limit connectivity within this area (compared to the Minidoka reach population).

Overall, while the two general population areas for the Snake River physa are isolated at times with limited connectivity opportunities, we do not have information suggesting that the small population size, habitat fragmentation, and loss of connectivity are factors having a direct impact on the species at this time.

Summary of other natural or manmade factors affecting its continued existence: The invasive New Zealand mudsnail has become established and is widely distributed in the Snake River and its tributaries; however, we do not have information that New Zealand mudsnails are impacting the Snake River physa or its habitats. The Minidoka reach population of Snake River physa is regarded as isolated, and opportunities for immigration and emigration into the population are severely limited which makes this population susceptible to natural and manmade stochastic events. Connectivity between the Minidoka reach population and populations further downstream are limited due to the presence of Milner, C.J. Strike, and Swan Falls Dams. While there are sources of fragmentation which isolate populations throughout the range of the Snake River physa, we are still unclear what factors may limit its distribution. Therefore, we cannot determine whether small population size, habitat fragmentation, and loss of connectivity occur at a scale that currently affects the Snake River physa or its habitat.

2.4 Synthesis:

At the time of the 1992 listing, the range of the Snake River physa was considered to be the Snake River in southern Idaho, from near Grandview upstream through the Hagerman reach, with a possible population downstream of Minidoka Dam. Between 1992 and 2006, no live Snake River physa were known to have been collected at any location within the Snake River. Based on the results of numerous aquatic snail surveys since 1992, the current known range of Snake River physa is now known to occur between Ontario, Oregon upstream to Minidoka Dam, Idaho, which is an increase of approximately 356 RKM (221 RM) in the range of the species since the time of listing. The species remains patchily distributed and is generally found at low densities where it occurs.

The Snake River physa has only been found within the Snake River itself. Suitable habitat includes pebble to gravel substrates, and possibly cobble to gravel, that are largely free of macrophytes and substrates finer than gravel which can fill in the interstitial spaces. While its specific water temperature tolerance is unknown, the Snake River physa has been collected in areas where average water temperatures ranged from 22.6 °C (72.7 °F) – 23.4 °C (74.1 °F), temperatures that exceed the Idaho's temperature standard for cold water biota (22.0 °C (71.6 °F)).

Within the Minidoka reach the Snake River physa population is considered to be relatively robust and stable, and has been successfully collected annually between 2006-2008 and in 2012. Recent downstream surveys have failed to find the species within the Lower Salmon Falls Dam to Ontario, Oregon, reach where the Snake River physa was last documented in 2003. The inability to collect the species is likely due to several factors, including limited survey effort, and limited habitat with more degraded conditions. Additional survey effort for the species outside of the Minidoka reach may help further refine the species' known distribution and population status.

At the time of listing in 1992, the primary threats to the Snake River physa included construction of new hydropower dams, operation of existing hydropower dams, water quality degradation, water diversions and groundwater withdrawals for agriculture and aquaculture, small hydroelectric development, lack of State regulations, pollution regulations, Federal consultation regulations, and competition with the non-native New Zealand mudsnail. There has been a lot of new information gathered regarding the factors affecting the Snake River physa since the 1992 listing. Earlier proposals for the construction of 8 hydropower dams within the range of the species have been abandoned and none are being considered at this time. The increasing demand for additional water storage reservoirs has been suggested, especially in light of climate change concerns – but there are no proposals currently undergoing any regulatory review. In addition, conversely to the final rule, the exotic New Zealand mudsnail does not appear to either compete or affect the Snake River physa given the two species preferred habitats do not appear to entirely overlap.

Additional, new information regarding the favored habitats of the Snake River physa has led us to determine that multiple factors including operations of existing dams, degraded water quality, and climate change currently constitute the primary threat to the species. The effect from degraded water quality is not uniform throughout the species range, but appears to be affecting the species distribution and suitable habitat more so outside of the Minidoka reach. This is likely due to decreased water flow during summer months outside of the Minidoka reach, while increased flows during summer in the Minidoka reach keep substrates relatively free of fine sediments and resulting macrophyte growth. Lastly, while Federal consultation is now required for the Snake River physa through section 7 of the ESA, the inadequacy of existing regulatory mechanisms continues to threaten the Snake River physa due to the lack of State regulations specific to the species, along with inadequate water quality and invasive species regulations.

3.0 RESULTS

3.1 Recommended Classification:

The understanding of the known geographic range of the Snake River physa has increased since the time of listing. Surveys have shown the species to be relatively widespread in the Snake River, occurring in approximately 494 RKM (307 RM); from Minidoka Dam to Ontario, Oregon. Since the time of listing in 1992, no new dams have been built and we are not aware of any proposed new dams on the Snake River that would further alter the species habitat. Water quality degradation, including elevated nutrient loads and sedimentation continues to affect the species habitat primarily within the Lower Salmon Falls to Ontario, Oregon reach, while seasonal flushing flows in the upper reach of the Snake River maintains suitable habitat free of sediments and macrophytes. Due to these suitable habitat conditions, the population size and status of the Snake River physa within the upper Snake River in the Minidoka reach appears to be relatively robust as well as stable. Conversely, the Snake River physa has not been found in the remainder of its range from Lower Salmon Falls Dam to Ontario, Oregon, since 2003, though survey efforts have been limited. Since the Snake River physa is rarely found at high densities, survey efforts may have been inadequate to detect the species in the Lower Salmon Falls Dam to Ontario, Oregon reach.

The Act defines an endangered species as any species that is "in danger of extinction throughout all or a significant portion of its range" and a threatened species as any species "that is likely to become endangered throughout all or a significant portion of its range within the foreseeable future." Our general understanding of an "endangered" species is one that is currently on the brink of extinction in the wild. Due to the extensive monitoring and surveys that have been conducted by Idaho Power and Bureau of Reclamation, our current knowledge of the Snake River physa indicates the species is: 1) known to occur over a relatively large area of the Snake River – from Minidoka Dam to Ontario, Oregon; about 494 RKM (307 RM), and 2) appears to be robust in population numbers and stable within the Minidoka reach. Lastly, there are no new proposed hydroelectric or water storage facilities proposed in the Snake River that would alter flows or water quality within the range of these species. From our analysis in the 5-year review, we have determined that the threats affecting the Snake River physa and its habitat do not currently rise to the level that the species is in danger of extinction. Therefore, we recommend that the status of the Snake River physa be downlisted from endangered to threatened.

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

3.2 New Recovery Priority Number: 8c

Brief Rationale:

The Snake River physa is considered a distinct species. Surveys from the time of listing in 1992 to 2006 were not able to detect the species which indicated it was extremely rare or possibly extirpated throughout its range. Currently, we consider the Snake River physa to be relatively widespread, although not abundant within the Snake River. For these reasons, we have determined the Snake River physa and its habitat continue to face a moderate degree of threat factors, and have a high recovery potential, providing this species with a recovery priority number of 8c.

3.3 Listing and Reclassification Priority Number:

Reclassification (from Threatened to Endangered) Priority Number: ____
Reclassification (from Endangered to Threatened) Priority Number: _6__
Delisting (Removal from list regardless of current classification) Priority Number: ____

Brief Rationale:

Reclassification from endangered to threatened will retain most of the same protections afforded by the Act. In addition, future Section 7 consultation would be similar for a threatened versus endangered species. Thereby a reclassification will likely have none to low management impact to federal and non-federal agencies and the public. Lastly, this was not a petitioned action. Therefore, we have chosen a reclassification priority number of 6.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

1. Gather, through research and surveys, additional information regarding basic biology and known range. Much remains unknown regarding the basic biology of the Snake River physa, including reproduction and life history traits, and diet preferences. In addition, surveys for presence within their current range have been limited in extent, especially outside of the Minidoka reach. Additional survey effort is needed in areas where they have been recently collected, particularly downstream of C.J. Strike and Swan Falls Dams, and within the Bruneau arm of C.J. Strike Reservoir.

2. Given the existing monitoring of Snake River physa below Minidoka Dam is a 5-year effort that was initiated in 2012, we recommend continued monitoring of that population, beyond the present effort, to further track population trends. In addition, if the Snake River physa can be reliably collected outside of the Minidoka reach, a monitoring program should be established in those areas to obtain population trends at a larger, rangewide scale.

3. Revise the Snake River Aquatic Species Recovery Plan with objectives and measurable criteria that are specific to the Snake River physa.

4. Additional work is needed to address factors that have led to the degradation of the Snake River physa's habitat. Actions may include decreasing nutrients, such as TP, and suspended sediment inputs to the Snake River from certain land uses within its range, while reducing existing substrate embeddedness and excessive macrophyte growth by modifying dam operations to enhance seasonal flows (i.e. increasing river flows during the summer months) in certain areas of their range.

5.0 REFERENCES

Alexander, J.E., Jr., and A.P. Covich. 1991. Predator avoidance by the freshwater snail *Physella virgata* in response to the crayfish *Procambarus simlans*. Oecologia 87:435-442.

Armitage, P.D. 1984. Environmental changes induced by stream regulation and their effect on lotic macroinvertebrate communities. pp. 139- 162 *in* Regulated Rivers. Chapter from Regulated Rivers, edited by Lillehammer, A. and S.J. Saltveit. Oslo University Press, Oslo, Norway.

Bahr. G. and Carlson, R. 2000. Ground Water Quality of Twin Falls County Volcanic and Sedimentary Aquifer. Idaho State Department of Agriculture Technical Results Summary #2. 3 pp.

Bowler, P.A., C.M. Watson, J.R. Yearsley, and P.A. Cirone. 1992. Assessment of Ecosystem Quality and its Impact on Resource Allocation in the Middle Snake River Sub-Basin. Proceedings of the Desert Fishes Council. Volume XXIV.

Brusven, M.A. 1985. The Distribution and Abundance of Benthic Insects Subjected to Reservoir-release Flows in the Clearwater River, Idaho, USA. Chapter from Regulated Rivers, edited by Lillehammer, A. and S.J. Saltveit. Oslo University Press, Oslo, Norway.

Brusven, M.A., C. MacPhee, and R. Biggam. 1974. Benthic Insects (Effects of Water Fluctuation on Benthic Insects). Chapter 5 from Anatomy of a River. Pacific Northwest River Basin Commission. Vancouver, Washington. pp. 67-79.

Brusven, M.A. and C. MacPhee. 1976. The Effect of River Fluctuations Resulting from Hydroelectric Peaking on Selected Aquatic Invertebrates and Fish. Research Technical Completion Report. Project A-035-IDA. Idaho Water Resources Research Institute. University of Idaho. Moscow, Idaho. 46 pp.

Clark, G. 1997. Assessment of Nutrients, Suspended Sediment, and Pesticides in Surface Water of the Upper Snake River Basin, Idaho

Clark, G.M. and D.S. Ott. 1996. Springflow effects on chemical loads in the Snake River, south-central Idaho. Water Resources Bulletin, American Water Resources Association 32(3): 553-563.

Clark, G.M., T.R. Maret, M.G. Rupert, M.A. Maupin, W.H. Low, and D.S. Ott. 1998. Water Quality in the Upper Snake River Basin, Idaho and Wyoming, 1992-1995. U.S. Geological Survey Circular 1160.

Clark, M.L., W.J. Sadler, and S.E. O'Ney. 2004. Water-Quality Characteristics of the Snake River and Five Tributaries in the upper Snake River Basin, Grand Teton National Park, Wyoming, 1998-2002. Scientific Investigations Report 2004-5017. U.S. Department of Interior, U.S. Geological Survey. 46 pp.

Covich, A.P., T.A. Crowl, J.E. Alexander, and C.C. Vaughn. 1994. Predator-avoidance responses in freshwater decapod-gastropod interactions mediated by chemical stimuli. Journal of North American Benthological Society 13(2): 283-290.

DeWitt, R.M. 1955. The ecology and life history of the pond snail *Physa gyrina*. Ecology 36(1): 40-44.

Dillon, R.T.J. 2000. The Ecology of Freshwater Molluscs. Cambridge University Press, Cambridge, United Kingdom.

Dillon, R.T.J. 2006. Freshwater Gastropods. pp. 251-259 *In* C.F. Sturm, T.A. Pearce, and A. Valdes, eds. The Mollusks: A Guide to their Study, Collection, and Preservation. Universal Publishers, Boca Raton, Florida.

Dillon, R.T.J., T. Earnhardt, and T. Smith. 2004. Reproductive isolation between *Physa acuta* and *Physa gyrina* in joint culture. American Malacological Bulletin 19: 63-68.

Dybdahl, M., A. Emblidge, and D. Brown. 2005. Final Report: Studies of a Trematode Parasite for Biological Control of an Invasive Freshwater Snail. 13 pp.

Escobar, J.S., B. Facon, P. Jarne, J. Goudet, and P. David. 2009. Correlated evolution of mating strategy and inbreeding depression within and among populations of the hermaphroditic snail *Physa acuta*. Evolution 63(11): 2790-2804.

Falter, C. M. and D.R. Hinson. 2003. Sediment and Benthic Community Characterization Below Agriculture and Aquaculture Waster Loadings in the Middle Snake River, South-Central Idaho. Idaho Department of Water Resources. 198 pp.

Federal Energy Regulatory Commission (FERC). 2010. FEIS for Hydropower License: Swan Falls Hydroelectric Project; FERC Project No. 503-048. Idaho. pp. 126.

FERC. 2012. Order Issuing New License for Swan Falls Hydroelectric Project No. 503. 67 pp.

Fisher, S.G. and A. LaVoy. 1972. Differences in littoral fauna due to fluctuating water levels below a hydroelectric dam. Journal of the Fisheries Research Board of Canada, 29 (10): 1472-1476.

Frest, T.J., P.A. Bowler, and R. Hershler. 1991. The Ecology, Distribution and Status of Relict Lake Idaho Mollusks and other Endemics in the Middle Snake River. Preliminary Report to the Idaho Fish and Wildlife Office, Boise, Idaho. 18 pp.

Gates, K.K., and B.L. Kerans. 2010. Snake River physa, *Physa* (*Haitia*) *natricina*, survey and study: Final Report. Department of Ecology, Montana State University, Reclamation Agreement 1425-06FC1S202, Bozeman, Montana.

Gates, K.K., and B.L. Kerans. 2011. Snake River Physa, *Physa* (*Haitia*) *natricina*, identification and genetics. Department of Ecology, Montana State University, Bozeman, Montana 59717, USA.

Gates, K.K., B.L. Kerans, J.L. Keebaugh, S. Kalinowski, and N. Vu. 2013. Taxonomic identify of the endangered Snake River physa, *Physa natricina* (Pulmonata: Physidae) combining traditional and molecular techniques. Conservation Genetics. 14: 159-169.

Gersich, F.M. and M.A. Brusven. 1981. Insect Colonization Rates in Near-Shore Regions Subjected to Hydroelectric Power Peaking Flows. Journal of Freshwater Ecology. 1(2): 231-236.

Gislason, J.C. 1980. Effects of Flow Fluctuation Due to Hydroelectric Peaking on the Benthic Insects and Periphyton of the Skagit River, Washington. Ph.D. Dissertation. University Washington, Seattle, Washington. 163 pp.

Grafe, C.S. editor. 2002. Idaho River Ecological Assessment Framework: An Integrated Approach. Idaho Department of Environmental Quality, Boise, Idaho.

Groves, P.A., and J.A. Chandler. 2005. Habitat quality of historic Snake River fall Chinook salmon spawning locations and implications for incubation survival. Part 2: Intra-gravel water quality. River Res. Applic. 21:469-483.

Hall, R.O., J.L. Tank, and M.F. Dybdahl. 2003. Exotic snails dominate nitrogen and carbon cycling in a highly productive stream. Frontiers in Ecology and the Environment 1(8): 407-411.

Hall, R.O., M.F. Dybdahl, and M.C. VanderLoop. 2006. Extremely High Secondary Production of Introduced Snails in Rivers. Ecological Applications. 16(3): 1121-1131.

Hardy, M.A., D.J. Parliman, and I. O'Dell. 2005. Status of and Changes in Water Quality Monitored for the Idaho Statewide Surface-Water-Quality Network, 1989-2002. Scientific Investigations Report 2005-5033. Version 1.0. U.S. Department of the Interior, U.S. Geological Survey. 103 pp.

Hinson, D.R. 2006. Evaluation of Utah Valvata (*Valvata utahensis*) Status in the Snake River Basin, Idaho. Steward and Associates prepared for Barker Rosholt & Simpson LLP. 54 pp.

Idaho Department of Environmental Quality (IDEQ). 2000. The Lake Walcott Subbasin Assessment, Total Maximum Daily Load, and Implementation Plan. 241 pp.

IDEQ. 2010. Upper Snake Rock/Middle Snake TMDLs, HUC ID17040212, Upper Snake Rock TMDL Modification (2005), Upper Snake Rock Watershed Management Plan (2000) and Middle Snake River Watershed Management Plan (1997)), 5-Year TMDL Review. 99 pp.

IDEQ. 2011. Mid Snake River/ Succor Creek Subbasin, Five-Year Review of 2003 and 2007 Total Maximum Daily Loads. 52 pp.

IDEQ. 2012. Lake Walcott Subbasin Assessment and Total Maximum Daily Loads, Five-Year Review. 92 pp.

IDEQ. NA. 58.01.02 – Water Quality Standards. Idaho Administrative Code, Department of Environmental Quality. 180 pp.

Idaho Department of Fish and Game (IDFG). 2005. Idaho Comprehensive Wildlife Conservation Strategy. Idaho Conservation Data Center, Idaho Department of Fish and Game, Boise, ID. http://fishandgame.idaho.gov/public/wildlife/cwcs/

Idaho Invasive Species Council (IISC). 2007. Idaho Aquatic Nuisance Species Plan. A supplement to Idaho's Strategic Action Plan for Invasive Species. 145 pp.

IISC. 2012. The Idaho Invasive Species Strategic Plan. 2012-2016. 36 pp.

Idaho Power Company (IPC). 2011. Snake River Endangered Species Act Snail Sampling: 2010. Section 10 Report. Middle Snake River Projects. 230 pp.

Idaho State Department of Agriculture (ISDA). 2012. 2012 Program Summary. Idaho Invasive Species Program. 10 pp.

Idaho Water Resource Board (IWRB). 2010. Eastern Snake Plain Aquifer (ESPA), Comprehensive Aquifer Management Plan. 35 pp.

IWRB. 2012. Idaho State Water Plan. 90 pp.

IWRB. 2013. Eastern Snake Plain Aquifer (ESPA), Comprehensive Aquifer Management Plan, Progress Report: Overview & Accomplishments 2009-2012. 9 pp.

Ingersoll, C. 2006. Columbia Environmental Research Center (CERC) Quarterly Project Report for the Project entitled: "Protectiveness of aquatic life criteria for endangered species act listed gastropod molluscs". U.S. Geological Survey, Columbia Environmental Research Center, Columbia, Missouri. 4 pp.

Irving, R.B. and P. Cuplin. 1956. The Effect of Hydroelectric Developments on the Fishery Resources of Snake River. Idaho Fish and Game, Boise, Idaho. 174 pp.

Keebaugh, J. 2009. Idaho Power Company Physidae 1995-2003. Review Notes. Orma J. Smith Museum of Natural History, The College of Idaho. May. pp. 126.

Kerans, B.L., M.F. Dybdahl, M.M. Gangloff, and J.E. Jannot. 2005. *Potamopyrgus antipodarum*: distribution, density, and effects on native macroinvertebrate assemblages in the Greater Yellowstone Ecosystem. Journal of the North American Benthological Society. 24(1): 123-136.

Kjelstrom, L.C. 1992. Assessment of spring discharge to the Snake River, Milner Dam to King Hill, Idaho. Water Fact Sheet, Open File Report 92-147. U.S. Geological Survey. 2 pp.

Kosterman, M.A., D. Sharp, and R. Remington. 2008. Idaho Assessment of Ecological Condition: A Part of the EMAP Western Pilot Project. Idaho Department of Environmental Quality, Boise, Idaho.

Kroger, R.L. 1973. Biological Effects of Fluctuating Water Levels in the Snake River, Grand Teton National Park, Wyoming. American Midland Naturalist. 89(2): 478-481.

Link, P.K., D.S. Kaufman, and G.D. Thackray. 1999. Field guide to Pleistocene Lakes Thatcher and Bonneville and the Bonneville Flood, southeastern Idaho. Pages 251-266 *In* S.S. Hughes, and G.D. Thackray, eds. Guidebook to the Geology of Eastern Idaho, Idaho Museum of Natural History, Pocatello, Idaho.

Lodge, D.M., M.W. Kershner, and J.E. Aloi. 1994. Effects of an Omnivorous Crayfish (*Orconectes rusticus*) on a Freshwater Littoral Food Web. Ecology. 75(5): 1265-1281.

Lodge, D.M., R.A. Stein, K.M. Brown, A.P. Covich, C. Brönmark, J.E. Garvey, and S.P. Klosiewski. 1998. Predicting impact of freshwater exotic species on native biodiversity: Challenges in spatial scaling. Australian Journal of Ecology. 23: 53-67.

Martin, T.H., L.B. Crowder, C.F. Dumas, and J.M. Burkholder. 1992. Indirect effects of fish on macrophytes in Bays Mountain Lake: evidence for a littoral trophic cascade. Oecologia. 89: 476-481.

McMahon, R.F. 1975. Effects of Artificially Elevated Water Temperatures on the Growth, Reproduction and Life Cycle of a Natural Population of Physa Virgata Gould. Ecology. 56(5): 1167-1175.

Meitl, J.M. 2002. Five ESA Listed Snake River Aquatic Snails, Review of Information Developed From 1995 to 2001. Prepared for U.S. Fish and Wildlife Service, Snake River Office, Boise, Idaho. 80 pp.

Merrick, G.W., A.E. Hershey, and M.E. McDonald. 1992. Salmonid diet and the size, distribution, and density of benthic invertebrates in an arctic lake. Hydrobiologia. 240: 225-233.

Meyer, J.L., M.J. Sale, P.J. Mulholland, and N.L. Poff. 1999. Impacts of Climate Change on Aquatic Ecosystem Functioning and Health. Journal of the American Water Resources Association. 35(6): 1373-1386.

National Climate Assessment and Development Advisory Committee. 2013. Draft National Climate Assessment. 1193 pp.

Neely, K.W. 2005. Nitrate Overview for the Statewide Ambient Ground Water Quality Monitoring Program, 1990-2003. Idaho Department of Water Resources, Ground Water Quality Technical Brief. 14 pp.

Paerl, H.W. and J. Huisman. 2008. Blooms Like It Hot. Science. 320 (57): 57-58.

Paerl, H.W., N.S. Hall, E.S. Calandrino. 2011. Controlling harmful cyanobacteria blooms in a world experiencing anthropogenic and climate-induced change. Science of the Total Environment. 409: 1739-1745.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Sromberg. 1997. The Natural Flow Regime, A paradigm for river conservation and restoration. Bioscience. 47(11): 769-782.

Poff, N.L., M.M. Brinson, and J.W. Day, Jr. 2002. Aquatic Ecosystems and Global Climate Change. Potential Impacts on Inland Freshwater and Coastal Wetland Ecosystems in the United States. Prepared for the Pew Center on Global Climate Change. 44pp.

Rahel, F.J. and J.D. Olden. 2008. Assessing the Effects of Climate Change on Aquatic Invasive Species. Conservation Biology. 22(3): 521-533.

Rattray, G.W., A.J. Wehnke, L.F. Hall, and L.J. Campbell. 2005. Radiochemical and Chemical Constituents in Water from Selected Wells and Springs from the Southern Boundary of the Idaho National Laboratory to the Hagerman Area, Idaho, 2003. Open File Report 2005 – 1125 Version 2.1. U.S. Department of Interior, U.S. Geological Survey. 32 pp.

Richards, D.C. 2004. Competition between the threatened Bliss Rapids snail, *Taylorconcha serpenticola* (Hershler et al.) and the invasive, aquatic snail *Potamopyrgus antipodarum* (Gray). Ph.D. dissertation, Montana State University, Bozeman, Montana.

Richards, D.C., L.D. Cazier, and G.T. Lester. 2001. Spatial Distribution of Three Snail Species, Including the Invader *Potamopyrgus antipodarum*, in a Freshwater Spring. Western North American Naturalist. 61(3): 375-380.

Richards, D.C., C.M. Falter, and K. Steinhorst. 2006. Status Review of the Bliss Rapids Snail, *Taylorconcha serpenticola* in the Mid-Snake River, Idaho. Report to Idaho Power Company, Boise, Idaho. 170 pp.

Rieman, B.E., and D.J. Isaak. 2010. Climate change, aquatic ecosystems, and fishes in the Rocky Mountain West: Implications and alternatives for management. Gen. Tech. Rep.

MRSGTR- 250. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.

Rogers, D.C., and A.R. Wethington. 2007. *Physa natricina* Taylor 1988, junior synonym of *Physa acuta* Draparnaud 1805 (Pulmonata: Physidae). Zootaxa 1662:45-51.

Schorzman, K., J. Baldwin, and J. Bokor. 2009. Possible Sources of Nitrate to the Springs of Southern Gooding County, Eastern Snake River Plain, Idaho. Ground Water Quality Technical Report No. 38. Idaho Department of Environmental Quality, Technical Services and Twin Falls Regional Office. December 2009. 41 pp.

Sokolova, I.M. and G. Lannig. 2008. Interactive effects of metal pollution and temperature on metabolism in aquatic ectotherms: implications of global climate change. Climate Research. 37: 181-201.

Taylor, D.W. 1982. Status report on Snake River Physa snail. Prepared for the U.S. Fish and Wildlife Service. July 1, 1982.

Taylor, D.W. 1988. New species of *Physa* (Gastropoda: Hygrophila) from the western United States. Malacological Review 21: 43-79.

Taylor, D.W. 2003. Introduction to Physidae (Gastropoda: Hygrophila): Biogeography, classification, morphology. International Journal of Tropical Biology and Conservation Supplement 1:1-287.

U.S. Bureau of Reclamation (USBOR). 2013. ESA Section 10 Annual Report for WY 2012 – Monitoring and Distribution Surveys for Snake River Physa (*Physa natricina*) Snails Protected Under the Endangered Species Act in the Minidoka Reach of the Snake River, Idaho. U.S. Department of Interior, Bureau of Reclamation, Pacific Northwest Region, Snake River Area Office, Boise, Idaho. 32 pp.

U.S. Environmental Protection Agency (USEPA). 2002. Ecological Risk Assessment for the Middle Snake River, Idaho. Washington, D.C.

USEPA. 2007. Authorization to Discharge under the National Pollutant Discharge Elimination System: Aquaculture Facilities in Idaho, subject to Wasteload Allocation under Selected Total Maximum Daily Loads. U.S. EPA Region 10, Seattle, Washington. December 1, 2007. 96 pp.

USEPA. 2008. Chapter 6, Ecological Condition, 46 pp., *in* EPA's 2008 Report on the Environment.

USFWS. 1995. Snake River Aquatic Species Recovery Plan. U.S. Fish and Wildlife Service, pp. 92.

USFWS. 2004. Biological Opinion for the Federal Regulatory Commission Proposed Relicensing of Five Hydroelectric Facilities on the Middle Snake River, Idaho: Shoshone Falls (FERC No. 2778), Upper Salmon Falls (FERC 2777), Lower Salmon Falls (FERC

2061), Bliss (FERC 1975), and C.J. Strike (FERC 2055), and their Impacts on Five Mollusc Species and Bald Eagles. U.S. Fish and Wildlife Service, Boise, Idaho. 125 pp.

USFWS. 2005. Biological Opinion for Bureau of Reclamation operations and maintenance in the Snake River basin above Brownlee Reservoir. U.S. Fish and Wildlife Service, Snake River Fish and Wildlife Office, Boise, Idaho. pp. 342.

USFWS. 2012a. Biological Opinion for the Swan Falls Hydroelectric Project, FERC No. 503, 14420-2011-F-0318. U.S. Fish and Wildlife Service, Idaho Fish and Wildlife Office, Boise, Idaho. 82 pp.

USFWS. 2012b. Biological Opinion Regarding the Effects of the Federal Energy Regulatory Commission's Proposed License Amendments for the Lower Salmon Falls and Bliss Hydroelectric Projects on the Bliss Rapids Snail and Snake River Physa. U.S. Fish and Wildlife Service, Idaho Fish and Wildlife Office, Boise, Idaho. 108 pp.

Vaughn, B., P. Dionne, C. Hui, L. Nguyen, D. Search, and Y. Zhang. 2008. Land snails (& other air-breathers in Pulmonata subclass & Sorbeconcha clade), Accessed January 19, 2012 online at: http://shells.tricity.wsu.edu/ArcherdShellCollection/Gastropoda/Pulmonates.html

Wethington, A.R. and C. Lydeard. 2007. A Molecular Phylogeny of Physidae (Gastropoda; Basommatophora) Based on Mitochondrial DNA Sequences. Journal of Molluscan Stuies. 73: 241- 257.

Williamson, C.E., W. Dodds, T.K. Kratz, and M.A. Palmer. 2008. Lakes and Streams as Sentinels of Environmental Change in Terrestrial and Atmospheric Processes. Frontiers in Ecology and the Environment. 6(5): 247-254.

In Litt.

Buhidar, B.B. 2006. Preliminary Assessment of the Water Quality on the Middle Snake River in Southcentral Idaho. Idaho Department of Environmental Quality, Twin Falls Regional Office. 11 pp.

Burch, J.B. 2008. *Physa natricina* and the snail family Physidae in North America. Museum of Zoology, University of Michigan. PowerPoint presentation to the Bureau of Reclamation, Boise, Idaho. May 1, 2008. pp. 71.

Burch, J.B., T. Lee, and J.L. Keebaugh. 2010. Comparative morphology of *Physa* (*Haitia*) *natricina* Taylor 1988, an endangered freshwater snail. Museum of Zoology, University of Michigan, Ann Arbor. PowerPoint presentation, June 28, 2010. pp. 66.

Caswell, J. 2007. PowerPoint Presentation: Perceived Threat to Snails in 1992 regarding new hydroelectric development.

City of Twin Falls Data. 2013. Demographics for the city of Twin Falls, Idaho. Accessed January 29, 2013 online at: http://www.tfid.org/index.aspx?nid=101

Frest, T.J. 1991. Letter to Jay Gore, U.S. Fish and Wildlife Service, Boise Field Office. A review of two studies which reported the presence of Snake River physa upstream of prior reports. June 2, 1991. pp. 16.

Helder, D. 2013. February 25, 2013 Email from Dirk Helder, EPA, to Greg Burak, USFWS, regarding Administrative Extension of NPDES Permits for Idaho Aquaculture Facilities.

Idaho Department of Environmental Quality (IDEQ). 2013a. Ground Water in Idaho. Accessed April 10, 2013 online at: http://www.deq.idaho.gov/water-quality/ground-water.aspx

IDEQ. 2013b. Aquaculture in Idaho. Accessed July 25, 2013 online at: http://www.deq.idaho.gov/water-quality/wastewater/aquaculture.aspx

Idaho Power Company (IPC). 2012. Idaho Power Company Snake River physa data collection spreadsheet. Received: April 24, 2012.

Johnson, G., D. Cosgrove, and M. Lowell. 2013. Snake River Basin: River-Land Use Data. Accessed April 24, 2013 online at: http://imnh.isu.edu/digitalatlas/hydr/snakervr/srblud.htm

Newman, R. 2011. Email exchange and notes from a conversation with Ryan Newman, biologist with the U.S. Bureau of Reclamation, Minidoka Dam, regarding sediment and macrophyte growth downstream of Minidoka Dam where Snake River physa were found. December 7, 2011.

Newman, R. 2012. Email exchange between Ryan Newman, biologist with the U.S. Bureau of Reclamation, and Dave Hopper, U.S. Fish and Wildlife Service, regarding Snake River Physa surveys in the Neely Reach. January 9, 2012.

Ondrechen, B. 2004. Email from Ellen Berggren (U.S. Bureau of Reclamation) to Michael Morse (USFWS) regarding personal communication between Ellen Berggren and Bill Ondrechen (Idaho Department of Water Resources).

Pentec Environmental, Inc. 1991. Distribution survey of five species of mollusks proposed for endangered status in the Snake River, Idaho during March 1991. Final Report Pentec Project Number 00070-001. Prepared for Idaho Farm Bureau. Boise, Idaho. pp. 22.

Richards, D. 2002. Snail Conservation Plan Technical Committee (SCPTC) Meeting notes. June 26, 2002.

University of Idaho. 2007. Eastern Snake River Plan Surface and Ground Water Interaction. Accessed June 28, 2007 online at: http://www.if.uidaho.edu/~johnson/ifiwrri/sr3/esna.html

U.S. Bureau of the Census. 2013. Excel spreadsheet of County Population Census Counts for Cassia, Gooding, Jerome, Minidoka, and Twin Falls Counties, Idaho.

U.S. Department of Agriculture (USDA). 2013. Excel spreadsheet of cattle statistics in 1992 and 2012 for Cassia, Gooding, Jerome, Minidoka, and Twin Falls Counties, Idaho. Data accessed at: http://www.nass.usda.gov/Quick_Stats/Lite/

U.S. Environmental Protection Agency (USEPA). 2013a. Nonpoint Source: Introduction. Accessed April 18, 2013 online at: http://water.epa.gov/polwaste/nps/nonpoin1.cfm

USEPA. 2013b. Wastewater Discharge Permits. Region 10: the Pacific Northwest. Accessed April 18, 2013 online at: http://yosemite.epa.gov/R10/WATER.NSF/NPDES+Permits/Permits+Homepage

USEPA. 2013c. Clean Water Act § 303(d) List of Impaired Waters. Accessed July 25, 2013 online at: http://yosemite.epa.gov/R10/WATER.NSF/tmdls/cwa+303d+list

Winslow, D. 2013. Excel spreadsheet of Physa natricina data calculations and summary based on Idaho Power Company data.

Yost, J. 2013. History of Milner Dam by Joe Yost-Dam Tender. Accessed April 23, 2013 online at: http://www.tfcanal.com/milner.htm

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of the *Snake River physa*

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

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

Appropriate Listing/Reclassification Priority Number, if applicable: 6

Review Conducted By: Idaho Fish and Wildlife Office, Boise, Idaho

FIELD OFFICE APPROVAL:

State Supervisor, Idaho Fish and Wildlife Service

Approve Michael Carrier Date 5/23/14