

An update to the Roanoke Loggerhead Recovery Plan

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Document Purpose and Intent

The purpose of this document is to provide information that could support a revision of the Roanoke Logperch Recovery Plan (USFWS 1992). Its primary intent is to comprehensively review research regarding the ecology, conservation, and status of this species to provide the most up-to-date information for such a document. This update also provides research and recovery recommendations in light of the review but is not intended to unequivocally replace the recovery objectives and benchmarks listed in the original Recovery Plan. A rigorous monitoring approach is key to the recovery process; therefore this document contains monitoring recommendations. However, creating an extensive, detailed, and explicit monitoring plan is outside of the intent of this document. Finally, this document contains no raw data. Instead, it is intended to summarize data from various sources that can be referred to for specific information such as maps, stream lengths, or absolute numbers of fish captured.

Summary

The Roanoke logperch (*Percina rex*) was listed as an endangered species on August 18, 1989 (54 FR 34464). This species is endemic to Virginia and its range is limited to 6 disparate populations within Virginia's Roanoke and Chowan river drainages. Within the Roanoke drainage, Roanoke logperch are found in the Roanoke River drainage upstream of Smith Mountain Lake, the Roanoke River drainage downstream of Leesville Reservoir, the Pigg River drainage, and the Smith River drainage. Within the Chowan system, a population of Roanoke logperch can be found in the Nottoway River drainage along the fall zone between the Piedmont and Coastal Plain physiographic provinces. All of the existing populations of Roanoke logperch are threatened by road projects, water projects, catastrophic spills, and siltation from agricultural runoff. Populations in the Roanoke River drainage are further threatened by urbanization and industrial development. Recent studies of the distribution and habitat use of Roanoke logperch suggest that this species is subject to riverwide stochastic processes and has strict microhabitat requirements. The distribution of habitat types and pathways of dispersal are critical for maintenance of healthy populations. Along with a stronger monitoring program, this document proposes a multi-tiered approach for recovery of the Roanoke logperch based on literature review and expert opinion.

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Section I. DESCRIPTION

Taxonomy

The Roanoke logperch (*Percina rex*) is considered the 'king' of darters (Jenkins and Burkhead 1993). Its large size, long life span, and feeding behaviors make it a particularly fascinating member of the logperch subgenus. Roanoke logperch were first collected from the Roanoke River in 1888. It was described and named *Etheostoma rex* by Jordan and Evermann (Jordan 1889). It was later placed in the genus *Percina* along with all of the other logperches, of which the geographically distinct blotchside logperch (*P. burtoni*) is its closest relative (Simonson and Neves 1986; Jenkins and Burkhead 1993). This species is probably a relict survivor of logperch stock that dispersed to the Roanoke River basin from the New River basin (Ohio River drainage; Jenkins and Burkhead 1993).

Morphology

Complete descriptions of the Roanoke logperch are available in Jordan (1889), Burkhead and Jenkins (1991), and Jenkins and Burkhead (1993). To summarize, this species is a large darter (adults 88-115 mm SL) with a long, conical snout, inferior mouth, and a moderate to robust body form. Its color in life is pale to yellow-olive with a white belly. Blotches on its side are strong and vertically elongate, and its back is much scrawled with small saddles. It has strongly tessellated fins and an orange to orange-red band on its first dorsal fin, which is particularly brilliant in nuptial males.

Feeding Behavior

Like all logperches (subgenus *Percina*), the Roanoke logperch is a diurnal, visual predator that forages by flipping stones with its conical snout to reveal

aquatic insects (Jenkins and Burkhead 1993); Roanoke logperch have also been observed flipping other types of debris, including wood and bark (Rosenberger and Angermeier 2002). This behavior appears very early in its life history; very small (< 4 cm), Age-0 logperch have been observed flipping small gravel (Rosenberger and Angermeier 2003). Although flipping stones is the primary method of foraging, logperch have been observed feeding above the bottom (Jenkins and Burkhead 1993) or grazing on woody debris (A. Rosenberger, personal observation). Feeding habits and stomach contents are described by Burkhead (1983), whose study indicated that this species is an opportunistic macroinvertebrate feeder that consumes most food items encountered.

Growth and Reproduction

Roanoke logperch males mature in 2 years, and females mature in 2-3 years. They have a long life span compared to other members of its family (up to 6.5 years; Jenkins and Burkhead 1993). Recent data collected by Roberts and Angermeier (2006) and Rosenberger and Angermeier (2002) indicate that previously used cutoffs for logperch age classes in the Roanoke and Chowan drainages (e.g., Rosenberger and Angermeier 2003; Roberts and Angermeier 2004) were erroneous (previously used total-length cutoffs: Summer: < 40 mm = young-of-the-year [YOY], 40-80 mm = juveniles, and > 80 mm = adults; Autumn: < 55 mm = YOY, 55-95 mm juveniles, and > 95 mm adults). Growth patterns of logperch have been examined for the Roanoke (Roberts and Angermeier 2006; Rosenberger and Angermeier 2002), Pigg, and Nottoway rivers (Rosenberger and Angermeier 2002). These more recent data suggest that logperch grow much more quickly in their first summer than previously assumed, and Age 1+ fish are not immediately distinguishable from older age classes based on the length of those individuals (new, more accurate total-length cutoffs: Summer \leq 80 mm, Autumn \leq 95 mm = YOY, larger individuals = Age 1+).

Based on dissection and observation of ripe gonads, spawning likely occurs in April-May in the upper Roanoke River (Burkhead 1983). The spawning season for other populations of logperch are unknown and may vary, particularly for the Nottoway River, which has a different climate and flow regime (see Research Needs). Different thermal or flow cues may affect onset of reproductive behavior. Eggs are adhesive and demersal and are buried with no subsequent parental care (Jenkins and Burkhead 1993).

Section II. DISTRIBUTION AND ABUNDANCE

Known Present Distribution

Knowledge of the distribution of Roanoke logperch has grown since it was first listed as endangered in 1989, but its geographic range remains small (Lahey and Angermeier 2006a). It is hypothesized that Roanoke logperch historically occurred contiguously throughout the Roanoke and Chowan watersheds prior to European settlement of Virginia. The species is now disjunctly distributed in the Roanoke Watershed in the Roanoke, Pigg, and Smith river drainages. It is also present in the Chowan Watershed in the Nottoway River drainage.

Logperch within each of these river drainages can be further subdivided among various tributaries and mainstem sections that are isolated from one another to varying degrees by man-made barriers and/or reaches of unsuitable habitat. The resulting population structure of this species is complex, and, to varying degrees, artificial, thus complicating determination of the number of “populations” for describing logperch ecology as well as setting recovery objectives and assessing whether these goals have been met.

For purposes of this document, we parsimoniously treat occupied areas not separated by a major dam as comprising a “population,” making for 6 total populations of Roanoke logperch: (1) the upper Roanoke River drainage upstream of Smith Mountain Reservoir; (2) the middle Roanoke River drainage

downstream of Leesville Reservoir; (3) the Pigg River drainage; (4) the Smith River drainage upstream of Philpott Reservoir; (5) the Smith River drainage downstream of Philpott Reservoir; and (6) the Nottoway River drainage.

Localities within these 6 major populations may be isolated to a varying extent by man-made barriers and/or unsuitable habitat. Designation as a separate population will require further investigation (e.g., genetic analysis). Candidate localities include: the Smith River downstream of Martinsville Dam, Town Creek, Goose Creek, and the Big and Little Otter rivers.

Unoccupied but suitable locations

Potential Roanoke logperch habitat within its probable range prior to human development of the region have been identified in the Dan, Mayo, Blackwater, Falling, and Meherrin river drainages; however, surveys of potential habitat have not revealed any logperch at these localities (Lahey and Angermeier 2006b). This does not necessarily mean that logperch are not present at these locations; low sampling efficiencies means that the detectability of this species is very low without extensive and intensive effort and the likelihood of false absences high when logperch are present at low densities.

Upper Roanoke River

The upper Roanoke River population of logperch is relatively large and continuously distributed throughout the North Fork, South Fork and mainstem Roanoke River in and near the City of Roanoke. A detailed report of logperch distribution in the North Fork Roanoke River indicates that logperch can extend 35.6km upstream of the confluence of the North and South Forks with the mainstem River (Ferguson et al. 1994). Logperch have also been found in Mason and Tinker creeks, tributaries to the Roanoke River (Burkhead 1983; Simonson and Neves 1986); however, recent surveys in Mason Creek have revealed no logperch. Urban development or other related causes in the creek watershed may have extirpated logperch from this locality, or effort may have been insufficient for detection (Lahey and Angermeier 2006a). Niagara Dam in

Roanoke County is generally considered the downstream extent of logperch in the upper Roanoke River (Lahey and Angermeier 2006b); however, several isolated specimens of logperch have been captured in the Niagara Dam tailwater before it enters Smith Mountain Lake (B. LaRoche, personal communication). Isolated specimens of logperch were also found in Beaverdam Creek Cove and Moorsman's Cove of Smith Mountain Reservoir, Bedford County, and in the Roanoke (Staunton) River, Campbell County, near Brookneal Hatchery (Miller and Morton 2000).

Middle Roanoke River

In the middle Roanoke River drainage, logperch have been captured in Goose Creek, Bedford County, close to the Huddleston Gauging Station (Lahey and Angermeier 2006b). Goose Creek enters the Roanoke River 120 river kilometers downstream of the downstream extent of the upper Roanoke River population. Logperch have also been found in the Little Otter River, a tributary of Big Otter River, which enters the Roanoke River downstream of the Goose Creek confluence (Lahey and Angermeier 2006b) and in the Big Otter River close to its confluence with the Little Otter River (J. Roberts, personal communication). The close proximity of the tributaries' confluences with the Roanoke River implies a potential connection between the localities and the potential for logperch to be in the mainstem river and other tributary locations.

Pigg River

The Pigg River also supports a population of Roanoke logperch (Rosenberger and Angermeier 2002) along with a rich assemblage of native species (Lahey and Angermeier 2006b). This population extends slightly upstream of the City of Rocky Mount and likely continues as far downstream as its confluence with Leesville Reservoir. Only one of its tributaries, Big Chestnut Creek, is known to contain logperch (Lahey and Angermeier 2006b).

Smith River populations

A population of logperch, along with a rich native assemblage, is found in the mainstem Smith River upstream of Philpott Dam (Lahey and Angermeier 2006c). Some of the larger tributaries of the Smith River upstream of the dam may also contain logperch, such as Rockcastle Creek (S. Smith personal communication); however, this population has not been extensively studied.

Logperch have been captured 8.9-39 river kilometers below Philpott dam (Orth 2001; S. Smith, personal communication); density appears to increase with distance from the dam (Orth 2001). Hydropeaking and cold water from dam release in the summer months likely restrict logperch from persisting closer to Philpott Dam within the mainstem river. Logperch have also been observed downstream of Martinsville Dam on the Smith River almost to the state border with North Carolina (S. Smith, personal communication). It is possible that this logperch population extends into North Carolina, but that is unknown (S. Smith, personal communication)

Logperch can also be found in Town Creek, which enters the Smith River immediately downstream of Philpott Reservoir (D. Orth, M. Anderson, and S. Smith, personal communication). Although there are no major movement barriers between the Town Creek and the lower Smith River logperch populations, a large stretch of unsuitable habitat due to dam release may isolate Town Creek from likely recolonization should extirpation of this locality occur. It is possible, however, that individuals from Town Creek could be swept downstream and supplement the Smith River population below Philpott Reservoir. Movement upstream in the Smith River into Town Creek is also possible, but daily hydropeaking is likely to seriously limit upstream movement in the river close to the dam.

Nottoway River

A population of Roanoke logperch occurs in the Nottoway River and some of its tributaries in the Chowan drainage. The highest densities of logperch are found along the length of river crossing the fall zone between the Piedmont and

Coastal Plain physiographic provinces. The most upstream record of logperch in this system is from Fort Pickett; however, only one individual was observed (Angermeier and Rosenberger 2000). Surveys by McIninch and Garman (2002; from Lahey and Angermeier 2006b) between Fort Pickett and the more densely populated areas downstream implied that logperch may be continuously but sparsely distributed along the upstream reaches of the river between Fort Pickett and Dinwiddie county. Logperch may be found in the Nottoway River as far downstream as the border of Sussex County with Southampton County. Only three tributaries of the Nottoway River, Stony, Sappony and Waqua creeks, contain logperch (Lahey and Angermeier 2006b); of the three tributaries, Stony Creek probably has the highest densities of logperch (A. Rosenberger, personal observation). Tributaries in this drainage that flow west to east over the fall zone are more likely to contain high-gradient habitat riffles and runs that may be necessary for logperch to complete their life history. Most of the tributaries of the Nottoway River flow north-south and are small, low gradient, swampy tributaries that do not contain suitable habitat.

Past Distribution

Based on their present, disjunct distribution, Jenkins (1977) and Burkhead (1983) hypothesized that all populations of Roanoke logperch within the Roanoke drainage were historically larger and well connected. They suggested that fragmentation by large reservoirs and destruction of habitat due to massive siltation from agriculture and human development resulted in the current separation of logperch populations in the Roanoke drainage. It is also possible that, prior to European settlement and agricultural expansion in Virginia, the logperch range extended far into the Piedmont and occasionally connected the Nottoway River population with the Roanoke River population. Limited data suggesting low genetic divergence among the Roanoke, Pigg, Smith, and Nottoway river populations of logperch support the notion of a relatively recent separation (George and Mayden 2003); however, more genetic data is needed to establish exact relationships between the four populations

(see Research needs). It is also possible that logperch were once present in the Dan, Mayo, and Falling river watersheds.

Densities and Abundance

Regulatory processes often require information on absolute abundance of endangered animals when assessing recovery or impact. Unfortunately, obtaining reliable information on logperch densities and total abundance is extremely difficult and may have limited meaning for this species. Logperch are a sparsely and patchily distributed, benthic, and cryptic species, all of which make a comprehensive, reliable census of logperch abundance among and within rivers extremely difficult. Recent intensive surveys indicate that at sites where logperch are sparse, they are not captured in most electrofishing passes or in most riffle-runs (Lahey and Angermeier 2006). Snorkeling using a distance-weighted model as well as electrofishing are reasonable approaches for obtaining logperch densities at the site-scale (Ensign et al. 1995); however, a validation study that compares estimates of logperch densities against a known, unbiased baseline estimate of logperch abundance has not yet been completed (see Research Needs section). An examination of density estimates among sites and years in a long-term data set suggests that high streamflows that increase water depth and velocity could lower electrofishing capture efficiency of Roanoke logperch (Roberts and Angermeier 2004). Other characteristics of the habitat such as water conductivity, turbidity, vegetation, and substrate composition could also affect sampling efficiency using electrofishing or snorkeling; however, little is understood about the relative effects of any of these habitat characteristics on sampling efficiency for Roanoke logperch. Finally, most surveys of logperch target habitats preferred by larger individuals, and capture of YOY using electrofishing techniques is rare (Roberts and Angermeier 2006). Low capture of YOY using electrofishing gear suggests that Roanoke logperch do not recruit appreciably to electrofishing sampling gear until at least their first fall (Roberts and Angermeier 2006).

A long-term (8-year) data set collected in the Roanoke River as part of pre-construction monitoring for the Roanoke River Flood Reduction project suggests a great deal of seasonal and annual temporal variability in logperch densities, even within sites that remain relatively stable in habitat availability (Roberts and Angermeier 2006). High Age 1+ density and high Age-0 density sites are spatially disconnected, suggesting logperch have a high capacity for dispersal, either through larval drift or Age 1+ movements (Roberts and Angermeier 2004). These multiple lines of evidence suggest that temporal variability in logperch densities within sites may be driven by river-wide stochastic phenomena such as stream flow conditions, but this is not well understood (see Research Needs section). Spatial, among-site variability in logperch densities can also be high (Roberts and Angermeier 2006; Rosenberger and Angermeier 2002) and may be partially related to differences among sites in the availability of suitable microhabitat for summer feeding (Roberts and Angermeier 2004; Lahey and Angermeier 2006c) and partially related to longitudinal patterns within the stream (Roberts and Angermeier 2006). All of these factors suggest that power to detect impact or a significant decline in logperch abundances, even when using single sites as 'indicator sites', is extremely low and will require an extensive, baseline understanding of logperch densities, sustained, long-term sampling for detecting impact, and a better understanding of what natural factors contribute to year-class strength of Roanoke logperch (Roberts and Angermeier 2006).

The following sections are a description of logperch density in each of its populations in a relative rather than an absolute sense, as absolute numbers would be suspect and have limited meaning. It is unknown whether logperch are at maximum population densities that could be expected (logperch may naturally occur at low densities, as they are typically found) at any of these locations, since researchers are still not clear whether or not logperch are presently limited by demography, reach-wide environmental conditions such as stream flow, or growing or rearing habitat.

Upper Roanoke River

The largest population of Roanoke logperch is found in the upper Roanoke River. Several factors contribute to the overall strength of this population: 1) comparable or higher densities of logperch at monitored sites in the Roanoke River relative to comparable sites in the Nottoway, Pigg, and Smith rivers; 2) the longest stretch of contiguous river kilometers occupied by Roanoke logperch; 3) presence of logperch in multiple river tributaries, including the North and South forks of the Roanoke River and Tinker Creek, all of which could act as sources in the event of an extirpation of the species along a length of the occupied mainstem river (Ensign et al. 1997).

Middle Roanoke River

Goose Creek and the nearby Little and Big Otter rivers appear to be sparsely and patchily populated with logperch but have not yet been sampled extensively enough to determine relative population densities (Lahey and Angermeier 2006b).

Pigg River

Although surveys of the Pigg River in the past have indicated that logperch are rare in this system (James 1979, Jenkins and Burkhead 1993), more recent surveys indicate that Age 1+ logperch are found at only slightly lower densities in occupied sites in the Pigg River than in the Roanoke River (Lahey and Angermeier 2006a). However, young-of-year are rarely observed in the Pigg River (Rosenberger and Angermeier 2002). Extremely low densities and the rarity of logperch in past surveys of the Pigg River may be due to a chemical spill during 1975 in the middle portion of the Pigg River at Rocky Mount, Virginia that caused a catastrophic fish kill that extended 36 kilometers downstream (James 1979). Although logperch did recolonize previously occupied areas in the Roanoke River drainage within two years of a massive manure spill (Ensign et al. 1997), most of the length of the Pigg River known to be occupied

by logperch was affected by the 1975 spill, and only a small stretch of river and a small length of occupied river could have acted as a source for recolonization, which may have slowed the recovery process.

Smith River Populations

Roanoke logperch in the Smith River are separated into two populations by Philpott Reservoir and may be further fragmented by unsuitable habitat downstream due to dam operation. In the Smith River population upstream of the reservoir, a single site surveyed had comparable logperch densities to sites in the Roanoke River; remaining sites contained logperch at comparable densities to the Pigg River (Lahey and Angermeier 2006c; J. Roberts personal observation) or only single or no logperch (A. Rosenberger, personal observation). Downstream of the dam, logperch are found at low densities in Town Creek (D. Orth, M. Anderson, and S. Smith, personal communication) and in the Smith River 9-39 kilometers below the dam, where operations have less effect on river habitat (Orth 2001; S. Smith personal communication).

Nottoway River

Previous discussions of logperch densities assert that the highest densities of Roanoke logperch can be found in the Roanoke River (Jenkins and Burkhead 1993); however, analysis and trends suggest that the population in the Nottoway River, although existing along a shorter length of river, may occur at equal or greater densities (Rosenberger and Angermeier 2002). Further, large YOY logperch have been observed at high densities in the Nottoway River (Rosenberger and Angermeier 2002). It is possible that the relatively pristine condition of low velocity habitats that YOY prefer (Burkhead 1983; Rosenberger and Angermeier 2002) contribute to strong juvenile production in the Nottoway River. In tributaries of the Nottoway River, logperch in Stony Creek probably occur at densities comparable to the Pigg River (A. Rosenberger personal observation); logperch in Butterwood, Sappony, and Waqua creeks are probably sparsely distributed at low densities, but these streams are not well surveyed or understood (Lahey and Angermeier 2006b). High densities of Age

1+ individuals and YOY in the mainstem river, a tributary locale with comparable densities, pristine conditions in low-velocity habitats, and a lack of large dams indicate that the Nottoway River population is both strong and unique. However, the relatively short length of occupied river in this system make it vulnerable to large spills or any water projects that could impound swift-water areas or fragment the population. In addition, if the population in the entire Nottoway drainage (including tributaries) is extirpated, it cannot be recolonized by adjacent, similar populations.

Trends in Populations: Increasing, Steady, or Declining?

Current criteria for downlisting the Roanoke logperch from Endangered to Threatened are: 1) all populations are stable or expanding and protected from foreseeable threats (total number “populations” according to this document = 6); 2) abundance and/or range size is increased for the Roanoke River population and at least two other populations (USFWS 1992).

The present understanding of the logperch range and densities indicate that all populations extend further and are denser than previously assumed (Simonson and Neves 1986; Burkhead 1983). Populations in the upper Roanoke and Nottoway show comparably high densities of logperch (Rosenberger and Angermeier 2002) and high genetic diversity compared to other populations (George and Mayden 2003). However, a poor understanding of the baseline abundances of logperch at the time of listing makes it difficult to ascertain if the logperch populations are presently increasing, steady, or declining. All populations have probably decreased in range size and potentially densities over the past 200 years due to loss of habitat from widespread siltation from human development and agriculture and the creation of large reservoirs. The presence of a small, isolated population in the Smith River suggests that this species can persist over decades in very small areas; however, small populations can still be particularly vulnerable to environmental and demographic fluctuations over the long term.

Upper Roanoke River

The population of Roanoke logperch in the upper Roanoke River is probably the largest, most important population in this species' range as well as the most studied. It occupies the longest range of river kilometers and has a number of tributaries that contain logperch. Long-term data sets on logperch from the Roanoke River are valuable for understanding logperch population sizes, structure, and dynamics (Roberts and Angermeier 2006). Recent data indicates that this population is dynamic, but shows no signs of decline (Roberts and Angermeier 2006). However, all of the known threats to logperch (see Threats section) exist in the Roanoke River drainage and show no signs of disappearing or declining. Therefore, this population should still be considered vulnerable. Age-1+ habitat does not appear to be limiting population density at current levels (Roberts and Angermeier 2006). However, a loss of habitat from multiple projects in the region could exceed an unknown threshold and result in an eventual decline in logperch population densities (J. Roberts, personal communication).

Middle Roanoke River

Discovery of logperch in the Big and Little Otter rivers and Goose Creek locales are expansions of the known range of this species since it was listed; however, they are not well studied and it is unknown whether these populations are increasing, declining, or stable (Lahey and Angermeier 2006b).

Pigg River

The Pigg River population is showing signs of increasing in size and range since the large spill occurred in the system in 1975 (James 1979; Rosenberger and Angermeier 2002; Lahey and Angermeier 2006b). However, the population still remains small and isolated from the Roanoke River population and shows signs of lower genetic diversity (George and Mayden 2003), which may make it vulnerable to inbreeding or extirpation from

demographic or environmental stochasticity. Proposed road projects (I-73) and the existing road crossing in Rocky Mount make this population vulnerable to a variety of threats, particularly road development, urbanization, and chemical spills (see Threats section).

Smith River populations

The Smith River populations are vulnerable due to fragmentation from Philpott dam and small size, but its population size probably remains stable since the time this species was listed. The continuing operation of Philpott Dam and continued siltation from upstream agriculture indicates that threats have not been eliminated or declined for this population. An impoundment named “Charity Dam” was once proposed for the Smith River upstream of Philpott Reservoir (Jenkins and Burkhead 1993), but the project has not moved forward in recent years. If the project is resurrected and completed, it could pose additional threat and extirpate logperch upstream of Philpott Dam.

Nottoway River

The Nottoway River population was once considered highly vulnerable due to widespread siltation from agricultural and forestry activity in its watershed (USFWS 1992). Recent surveys indicate that these threats have declined and the population is increasing in range and in density (Rosenberger and Angermeier 2002). If agricultural and forestry activities in the area continue along their current trajectory of minimal siltation and avoidance of riparian areas along the fall zone of the Nottoway River, this population should remain stable and may continue to increase if habitat is currently limiting this population. Because the population occurs over a relatively small length of the river and because of the potential limitation of swift-water reproductive habitat (see habitat requirements below), this population is probably most vulnerable to any projects that withdraw water during the reproductive season to the point that swift-water habitat is eliminated. Dam construction could also impound the same habitats and fragment the population.

Section III. HABITAT USE

Differences in Habitat Availability Among Rivers Containing Logperch

For the Roanoke and Nottoway rivers, both meso- and microhabitat characteristics vary in ways that could affect logperch habitat use and limit the similarity of habitat use and life history patterns among these rivers (Rosenberger and Angermeier 2002). Mesohabitat characteristics refer to the characteristics of pools, riffles, and runs in these high- to medium- gradient small rivers and streams (Frissell et al. 1986). Microhabitat characteristics refer to the characteristics of habitat in small, 1-m² areas within mesohabitats. There is presently little information available on mesohabitat characteristics of the Pigg, Smith, or Big and Little Otter Rivers or Goose Creek, but, because these streams are within the Roanoke drainage, mesohabitat availability is probably most similar to the Roanoke River as described below. Microhabitat availability is presently unknown for the Smith River, but visual examination suggests that the upper Smith River above Philpott Reservoir is probably most like the Pigg River as described below, though perhaps less silted, and the lower Smith River is probably most like the upper Roanoke River as described in microhabitat characteristics.

In addition, the following summaries are based on data collected between 1999-2000 (Rosenberger and Angermeier 2002). As human development patterns and management activities change through time, the relative difference in habitat characteristics may also change.

Mesohabitat availability differences between the Roanoke and Nottoway Rivers (summarized from Rosenberger and Angermeier 2002)

Differences between the Roanoke and Nottoway Rivers in mesohabitat characteristics reflect differences between the rivers in physiography, gradient,

and anthropogenic disturbance. Pool habitat is dominant, runs uncommon, and riffles are rare in the Nottoway River relative to the Roanoke River. The Nottoway River is a larger and wider system than the upper Roanoke River; therefore, runs and riffles are deeper in the Nottoway River. Within mesohabitats, the most consistent and dramatic differences between the two rivers are in embeddedness, silt cover, and frequency of woody debris. The Nottoway River has less anthropogenic disturbance in its watershed than the Roanoke River, and its riparian zone is relatively intact and almost completely lined with trees through the fall zone. This contributes woody debris and stabilizes banks in the Nottoway River, which, in turn, reduces sediment loads that cover and embed substrate. Exposed root wads, more common in Roanoke River riffles than Nottoway River riffles, are sometimes the result of undercutting that characterizes an unstable streambank. Past studies indicate that logperch avoid areas with heavy silt loads and substrate embeddedness, which are common in the Roanoke River. Choice of swift water with silt-free microhabitats by logperch in this system may compensate for the presence of habitats degraded by sedimentation.

Microhabitat availability differences between the Roanoke, Pigg, and Nottoway Rivers (summarized from Rosenberger and Angermeier 2002)

Differences among the Roanoke, Pigg, and Nottoway rivers reflect their relative size and gradient as well as differences among the systems in human development. The Roanoke and Pigg rivers are experiencing heavy sedimentation from nearby agriculture and construction activities, more so than the Nottoway River system. The Nottoway River is the largest and deepest of the rivers and the Pigg River the smallest and shallowest. The Roanoke River, with the highest gradient, has the largest substrates and highest bottom velocities in riffle microhabitats. The most dramatic differences among rivers are in embeddedness and silt characteristics. For all mesohabitat types, the Nottoway River has the least silted and embedded microhabitats and the Pigg River is most heavily embedded with silt.

Reproductive Habitat

Roanoke Drainage

Burkhead (1983) witnessed four spawnings in the upper Roanoke River when the water was between 12-14°C. These spawnings took place in a swift, deep runs over gravel and small cobbles. During the spawning season, males are found primarily in riffles and females in deep runs where spawning occurs (Burkhead 1983). No spawnings have been observed elsewhere in the Roanoke drainage.

Chowan Drainage

Reproductive habitat use outside of the Roanoke River is unknown. Although logperch are found primarily in low-velocity pools during the summer growing season in the Nottoway River (see following section), their distribution around the fall zone of the Piedmont and Coastal Plain physiographic provinces where riffle and run habitats are most common suggests that swift-water habitat is required at some life stage of this species. The proximity of logperch to the fall zone may be due to a requirement for swift-water habitat for spawning.

Summer Habitat Use

The descriptions below are based on Rosenberger and Angermeier (2002, 2003), with adjustments for new size designations for young-of-year (YOY) and age 1+ fish (Roberts and Angermeier 2006). Summer habitat use patterns most likely reflect habitat suitable for growth and survival, rather than reproductive habitat use, for this species. Habitat use data are available for Age 1+ individuals for the Pigg, Roanoke, and Nottoway rivers. For the Roanoke and Nottoway rivers, data are available for summer habitat use for

large YOY (TL > 4cm). For small YOY (TL < 4cm), data are available only from the Roanoke River.

Roanoke Drainage

While Roanoke logperch appear to select specific habitat configurations, this species uses a wide range of habitats in the Roanoke River over its ontogeny. In the Roanoke drainage, logperch habitat use in the summer varies with age; younger age classes tend to choose slower velocity habitats than older age classes, which prefer swift water with clean gravel and cobble bottoms. Age 1+ logperch in the Roanoke River are frequently observed in runs, occasionally in riffles, and rarely in pools. Within habitat units, Age 1+ logperch primarily use deeper areas (15-74cm), with medium to high water velocities, often directly over gravel substrate in areas dominated by cobble. In mid-summer, large YOY logperch greater than 4 cm TL have been observed primarily in runs, over moderately embedded gravel, in shallower and lower velocity habitats than the Age 1+ individuals. They were also observed occasionally in riffles and pools. Small YOY logperch less than 4 cm TL, in contrast, have been observed in nearly stagnant areas such as backwaters and secondary channels as well as the shallow margins at the tails of pools. These small individuals were found in water around 20 cm deep with small, slightly embedded substrate. A heavy silt blanket covered these areas; however, small logperch foraged in small patches of silt-free, loosely embedded gravel, potentially left by foraging bottom-feeders such as hogsuckers (*Hypentelium* spp.) or redhorse (*Moxostoma* spp.). Although individuals were often observed alone, all sizes of logperch have been observed in mixed- and single-species schools (particularly small YOY) and have been observed flipping small to large gravel while foraging for food.

Age 1+ logperch in the Pigg River, like the Roanoke River, have been observed primarily in runs, occasionally in riffles, and rarely in pools. Although logperch do not appear to preferentially select depth or bottom velocity categories in the Pigg River, Pigg River logperch exhibit a similar, but not identical, habitat use

pattern to the Roanoke River. Logperch in the Pigg River are found in slightly shallower water (19-48cm) than in the Roanoke River, which may be due to the fact that deep water habitat is less available in the Pigg River than the Roanoke River. Logperch in the Pigg River selected fast water habitats with exposed, silt-free gravel substrate.

Chowan Drainage

Roanoke logperch also use a wide range of habitats in the Nottoway River over ontogeny. Age 1+ and large YOY logperch in the Nottoway River have been observed primarily in pools and occasionally in runs. Few Age 1+ individuals and no large YOY were observed in riffle habitat. Both Age 1+ and large YOY logperch in the Nottoway River have been found over silt-free sand and gravel in deep, low velocity habitats. Although both large YOY and Age 1+ logperch in the Nottoway River were found over relatively exposed and lightly silted habitats, the large YOY were found in slightly more silted habitat with lower water velocities.

Summary

The ontogenetic shifts in habitat observed in the Roanoke and Nottoway rivers may be related to a variety of factors that affect individual survival, growth, and reproductive success; constraints such as predation pressure, feeding preferences, and swimming ability related to these parameters are likely to change over ontogeny (Werner and Gilliam 1984, Schlosser, 1987, 1988). Correlations between habitat variables and the presence/ absence or abundance of a species do not warrant causality conclusions; however, comparison between the two rivers reveals generalities about Roanoke logperch habitat use over life history. Habitat that is free of heavy siltation and contains moderately to loosely embedded substrate is preferentially used in the two systems. Large YOY in both rivers were found in slower velocity habitats than Age 1+ individuals, indicating that water velocity may be an important limitation for this life stage. The Nottoway River sites sampled in this study are in relatively pristine condition, and pools without heavy silt loads are

common. It is possible that logperch prefer low velocity, deeper habitats without silt, but that type of habitat is rare in the Roanoke River. Roanoke logperch in the Roanoke River inhabit a range of habitat types from rare to relatively common. Age 1+ individuals, in particular, seem capable of exploiting rare habitat that is deep, fast moving, and free of silt. In contrast, Roanoke logperch in the Nottoway River occupy habitat that is common and widespread, and habitat overlap between the two age classes is extensive. This indicates a potential habitat bottleneck in the Roanoke River for YOY logperch, which may require low-velocity habitat; YOY may be forced into microhabitats with embedded substrate suboptimal for foraging. It may be that river-wide flow processes are responsible for the amount of habitat available to YOY and may be the reason for large inter-annual variation in logperch densities (Roberts and Angermeier 2006).

Winter Habitat Use

Roanoke Drainage

Logperch have been observed using deep pools for winter habitat in the Roanoke River (temperatures < 8 °C; Burkhead 1983). More recent, but limited, observations suggest that this is not always the case; Age 1+ logperch observed in winter have been found in high-velocity, deep microhabitat in riffles and runs over exposed, silt-free gravel in areas dominated by cobble and boulder substrate (Rosenberger and Angermeier 2002). Logperch in these areas were quiescent in velocity shelters underneath larger substrates completely free of silt. Logperch may prefer to use low velocity, pool habitats in the winter as has been observed in the past (Burkhead 1983); however, most pools in the Roanoke River are heavily blanketed in silt (Rosenberger and Angermeier 2002), which may force logperch into velocity shelters in swift areas that are frequently flushed of silt. Logperch in the winter appeared to use slightly lower water velocities than logperch in the summer (Rosenberger and Angermeier 2002). Swimming ability of logperch in the winter may be limited due to cold temperatures that depress metabolism. Use of lower bottom

velocities and velocity shelters would reduce necessary activity for quiescent individuals. However, a shift into swift water areas may increase the likelihood of winter mortality in the case of a flood that would increase water velocities, move substrate, and potentially destroy velocity shelters of quiescent individuals.

Chowan Drainage

Winter habitat use outside of the Roanoke River is unknown; however, because temperatures in the Nottoway River drainage are typically warmer than the Roanoke River drainage, use of winter habitat is probably temporally shorter in this river than in the Roanoke drainage.

Movement Potential Through Habitats

A major gap in our knowledge of Roanoke logperch is the lack of information on movements by individual fish. This information is crucial to understanding habitat needs, the importance of movement for connecting habitats needed over ontogeny, and the implications of local extinction for regional persistence of logperch. A limited mark-recapture study of logperch revealed only short distance movement; however, the sampling design was inherently biased towards these types of movements (Rosenberger and Angermeier 2002). Recovery of logperch populations after catastrophic fish kills indicate that this species is capable of long-distance movements and successful reproduction that contribute to recolonization (Ensign et al. 1997), indicating that dispersal behavior may play an important (but unexamined) role in population persistence. More information regarding which ages are better dispersers and where they disperse could be obtained through movement or genetics studies and would greatly improve our understanding of logperch population dynamics (see Research Needs section). For example, they could improve our understanding of whether or not tributaries are important for maintaining mainstem populations of logperch and the potential for metapopulation dynamics in structuring logperch populations.

Section IV. THREATS

Several ecological characteristics of the Roanoke logperch make it particularly vulnerable to human impacts and alterations of stream environments:

- 1) The distribution of logperch is limited to a relatively small geographic area (Roanoke and Chowan drainages, Virginia).
- 2) The Roanoke logperch is a habitat specialist that depends on loosely embedded gravel for its feeding strategy, for all age classes and during all seasons, and is thus particularly vulnerable to silt deposition, a widespread human impact on Virginia rivers.
- 3) This species exists at low densities, is rarely locally abundant, and is patchily distributed throughout its range.
- 4) It requires multiple habitats over its ontogeny.

Other ecological characteristics of this species may have contributed to its continued persistence despite growing human impact on its environments:

- 1) Although a microhabitat substrate specialists, this species is capable of exploiting a variety of velocities and depths to find suitable feeding substrate and can also forage in woody debris.
- 2) Its relatively large size and drifting larvae could contribute to mobility and ability to recolonize areas where extirpation has occurred.
- 3) Logperch can be found not only in mainstem, medium-sized rivers, but also larger tributaries, which could enable recolonization of logperch following catastrophic extirpation in mainstem areas due to chemical spills (e.g., the Pigg River spill of 1975) or habitat destruction (e.g., hydropeaking and cold water release from Philpott Dam).
- 4) Populations of this species appear to be able to persist in small geographic areas.

The following section includes a discussion of known and potential threats to Roanoke logperch and the implications and degree of risk associated with each threat for each logperch population (summarized in Table 2). These threats include: 1) Large dams and reservoirs; 2) Siltation and habitat alteration and degradation from watershed urbanization; 3) Widespread sedimentation and siltation from agriculture and forestry; 4) Channelization projects; 5) Past and proposed road building; 6) Toxic chemical spills and fish kills; 7) Loss of riparian vegetation and woody debris; 8) Small barriers to logperch movement; and 9) Water withdrawals.

Table 2. A summary of threats listed in this document and the degree to which each population is at risk based on the particular threat (N = Not a present threat; L = Exists but not a large threat; M = Significantly threatens a subset of the range occupied by logperch; H = Significantly threatens the known range of the population; U = Unknown).

Threat	Population Upper Roanoke River	Middle Roanoke River	Pigg River	Upper Smith River	Lower Smith River	Nottoway River
Large dams	M	M	M	H	H	N
Urbanization	H	U	M	L	M	L
Ag./ Forestry	H	U	M	M	M	L
Channelization	M	U	N	N	U	N
Road Building	H	U	H	L	M	L
Toxic Spills	L	U	H	M	H	L
Riparian Loss	M	U	M	M	H	L
Small Barriers	L	U	M	U	U	U
Water Withdrawals	L	U	U	U	U	L

Large Dams and Reservoirs

Perhaps the greatest overall loss of logperch habitat and reduction in this species range in the Roanoke drainage occurred when Leesville and Smith Mountain reservoirs were completed in 1966. Along with habitat degradation from poor land use, the construction of these dams probably extirpated logperch populations within the Piedmont section of the Roanoke River

drainage, a hypothesis supported by the presence of logperch in Goose Creek and the Big and Little Otter River. In addition, populations of logperch in the Pigg and Smith Rivers were isolated from Roanoke River populations when these dams were constructed, increasing their vulnerability to extirpation and habitat loss by eliminating any chance of recolonization from upstream habitat.

Philpott Reservoir, which was constructed in 1953, is the greatest current threat to logperch within the Smith River. Upstream of the reservoir, the stretch of occupied river is small, isolated, and therefore vulnerable to other human impacts that affect instream habitat or cause local extirpation. Downstream of the reservoir, hydropeaking and coldwater release make at least 8 river kilometers completely unsuitable for logperch and potentially isolate Town Creek. Logperch in Town Creek could possibly be connected to logperch found 8-20km downstream of the dam; however, the connection between these two locales has not been investigated and cannot be assumed. Daily flooding from hydropeaking and unsuitably cold temperatures characterize the Smith River at its confluence with Town Creek. Any additional dam development upstream of Philpott, including the proposed but presently stalled Charity Reservoir (Jenkins and Burkhead 1993), could extirpate the logperch population upstream of Philpott Reservoir.

The Nottoway River is among the few rivers in Virginia located in the Piedmont and Coastal Plain physiographic provinces that do not have major barriers to movement in the form of lowhead dams or reservoirs along the relatively high gradient transition (fall zone) between the two provinces. Increasing development in the coastal areas around Newport News, Virginia could lead to increased interest in the relatively clean water found in this river system. However, impoundment of this river anywhere along the fall zone would seriously threaten its logperch population. Smaller dams upstream of the fall zone around the town of Blackstone are unlikely threats to the present range logperch and may actually protect downstream areas from sedimentation or

spills that originate near the town; however, they could cause isolation and restrict upstream range expansion.

Habitat Alteration and Degradation From Watershed Urbanization

Wheeler et al. (2005) reviewed the effect of urbanization on stream habitat. The following section is directly based on their review; contents of this review are compared against what is understood about the ecology of Roanoke logperch to summarize this growing threat to Roanoke logperch.

Urbanization fundamentally alters the delivery of water to streams and alters stream flow regimes. As a watershed urbanizes, peak flow volume from precipitation events increases, thereby increasing the frequency of bankfull flows. Increasingly severe flows could affect larval drift and year-class strength of Roanoke logperch, and flooding during the winter months could destabilize silt-free velocity shelters and increase overwinter mortality for this species.

The increased frequency of bankfull flows following urbanization causes a stream to increase its channel capacity by eroding its banks, downcutting its channel, or both (Wheeler et al. 2005). This increases the amount of fine sediment entering the stream. In addition, in a watershed with rapid development, construction projects are common, which have potential to dramatically increase the level of sediment entering streams. Although single projects are likely to have only temporary effects, continuous construction from multiple projects can sustain these effects. Excessive stream sedimentation reduces habitat heterogeneity, causes egg and larval mortality, abrades organisms, reduces visibility for sight predators, reduces macroinvertebrate productivity, and limits the rock-flipping feeding behavior of Roanoke logperch. Long stretches of river thickly covered with silt may act as barriers to movement and could fragment populations of logperch.

Impervious surfaces increase peak flow but decrease base flow. Base flows result from subsurface flow and groundwater that steadily contributes to streams between precipitation events. Because impervious surfaces prevent precipitation from infiltrating below the surface, urban streams are characterized by low base flows. Low flows combined with the effects of channel enlargement, results in urban streams that feature oversized stream channels with little water between runoff events. This reduces the availability of deep, swift water preferred by logperch for feeding, reproduction, and winter habitat.

Urbanization typically results in loss of streamside (riparian) vegetation as areas near streams are cleared. The degree of riparian disturbance can vary with type of urban land use; however, riparian vegetation is critical for stream function. The contribution of riparian vegetation to water quality (by filtering out chemicals, sediment, and stabilizing stream bank and shading water from temperature-increasing sunlight) and habitat (in the form of woody debris from falling riparian trees) indicates that urban projects that remove riparian trees along rivers inhabited by logperch could be detrimental for this species.

Rivers and streams receive the majority of urban runoff. Large quantities of stormwater drain from urban streets, parking lots, and lawns, containing a variety of pollutants (e.g., petroleum, heavy metals) and nutrients into the river. Pollutants can be stored in stream water and sediments and accumulate in stream biota; however, the extent to which this affects logperch populations is unknown (See Research Needs).

One of the worst threats of urbanization is that its effects are extremely difficult to reverse once they occur. Very low levels of urbanization (8%-10% of the watershed) result in highly altered stream habitat, and successful restoration of affected communities can be costly or near impossible, resulting in a shift into a new, less desirable state that is difficult to reverse. In contrast, although agriculture can have similar effects, streams may support relatively healthy fish

communities until agricultural land cover exceeds 80% of the watershed, and the effects of agriculture are easier to reverse through restoration activities (Wheeler et al. 2002).

Because projects that affect endangered species are typically evaluated on a one-by-one basis, and urbanization ultimately results from the 'tyranny of small decisions' (Odum, 1982), the cumulative effects of urbanization could be ignored for Roanoke logperch. Further, the cumulative effects of individual projects are overlooked by the Clean Water Act section 404 permitting process.

The human population in and around the Roanoke area, including Blacksburg and Salem, Virginia is continuing to expand. This is accompanied by the usual symptoms of watershed urbanization, including expanding impervious surfaces, increased urban sprawl, and loss of open areas and farmland. This could negatively affect all populations within the Roanoke River drainage, including ones in the Pigg and Smith rivers.

The area around the Nottoway River inhabited by Roanoke logperch is primarily used for agricultural or forestry purposes. The only areas that could be considered at all urban occur near the headwaters of the Nottoway River in and around the town of Blackstone. Urbanization is not one of the primary threats to logperch in this system at this time, but new development may become an issue as human populations in the area expand.

Widespread Siltation and Habitat Degradation from Agricultural Activities

The most widespread threat to Roanoke logperch is non-point source pollution in the form of fine sediment from both urban and agricultural activities. Particularly in the Roanoke drainage, crop and livestock farming contributes deposits of fine sediment and silt into the upper Roanoke, Pigg, and Smith rivers. In upstream reaches, cattle often have unrestricted access to the stream channel; as a result, failing and highly eroded streambanks are

common. However, widespread restoration activities and improved farming practices in these areas have a strong potential for dramatically reducing silt loads and improving logperch habitat. Restoration activities in agricultural areas are much more likely to be successful than in urban areas (See previous section on urbanization effects).

Historically, the Nottoway River was impacted by excessive siltation generated by poor agriculture and farming practices. Recent surveys indicate that both agriculture and forestry practices have improved along the Nottoway River, and siltation is less of an issue in this system than it is in the Roanoke drainage (Rosenberger and Angermeier 2002). Large hurricanes and subsequent high flow events that passed through the system may have assisted in flushing out any silt that would be a legacy of past impacts. Further, most of the streambank along the fall zone of the Nottoway River is forested (A. Rosenberger, personal observation). However, the highly erodible soils in the area, together with the potential for expanding agriculture and forestry, indicate that this threat could easily resurface. If siltation increases in the Nottoway River drainage, pools, which presently appear to be suitable for Roanoke logperch during the summer growing season, would be the mesohabitats most affected by deposition, and could potentially become unsuitable. This could force logperch into swift-water areas, but, because swift-water habitat is relatively rare within the low-gradient Nottoway River and becomes more rare as the summer progresses (Rosenberger and Angermeier 2002), this would considerably reduce the amount of available habitat for Age 1+ logperch and potentially eliminate suitable habitat for small and large YOY.

Channelization Projects

As stated in the original Roanoke logperch recovery plan (USFWS 1992), the morphology of rivers in the Roanoke drainage, particularly the upper Roanoke River, have been altered in many locations due to filling activities to support

industrial parks and residential areas and through small-scale channelization at local farms.

However, the largest project in extent in intensity that could affect Roanoke logperch is being conducted in Roanoke County along the entire length of the Roanoke River within the City of Roanoke limits by the U.S. Army Corps of Engineers. This project was proposed in 1989 but did not begin until fall of 2005. The purpose of this project is to protect property loss from flooding, particularly damage from small (~2 ft) floods. The objective of this project is to enhance the speed and volume of water conveyed downstream during floods by removing impediments to stream flow (instream wood), channel straightening, streambank stabilization (training walls and riprap), and physical widening of the floodplain at channel bends (K. Smith, personal communication).

The Roanoke River Flood Reduction Project will involve earth-moving activities that will likely temporarily increased sediment input into the rivers, and may therefore negatively effecting Roanoke logperch. Acute effects of the construction also include direct mortality from heavy equipment crossing the streambank.

Permanent alterations to stream habitat that the channelization project would cause could include: 1) loss of ability to move out fine sediment; 2) loss of peripheral, side-channel habitat in which small YOY logperch occur; and 3) loss of woody debris. It is possible that channel destabilization from the project will add more fine sediment than the channel can move. In that case, there may be a need to dredge the channel later, compounding the effects of the channelization project. All of these factors together could cause a decrease in logperch populations in and around the City of Roanoke during and after construction. This decrease may be delayed because much of the effect of the channelization project will be on YOY habitat (low-flow areas and side channels).

Past and Proposed Road and Highway Building

Urbanization and continued economic growth around the City of Roanoke, Salem, and town of Blacksburg has also resulted in an increase in new highway, highway improvement, and paved road projects. In particular, the Virginia Department of Transportation is proposing to build a highway (I-73) that will potentially impact all populations of Roanoke logperch in the Roanoke drainage. Paved road construction impacts on Roanoke logperch can be summarized in three dimensions: 1) road construction; 2) road presence; and 3) urbanization (Angermeier et al. 2004; Wheeler et al. 2005). Much of the discussion below is a summary based on more thorough literature reviews and conceptual arguments contained in Angermeier et al. (2004) and Wheeler et al. (2005), who reviewed the effects of road building, presence, and subsequent urbanization on stream biota and a report by Wheeler et al. (2002) that assessed via literature review the potential impact of the proposed I-73 on stream habitat and Roanoke logperch.

Road construction

During road construction, acute and heavy siltation can occur locally in nearby streams and rivers. Although mitigation techniques are available and required near stream habitat, they are not always properly maintained. After particularly heavy rainfall, preventative devices such as silt fencing can fail and result in localized extirpation of logperch through excessive sedimentation. Even with the presence of functioning silt fences, fine sediment loading can still increase in nearby streams (see previous sections for effects of siltation and fine sediment on Roanoke logperch). In addition, streams around bridges and highways are often channelized and straightened, which results in greater fine-sediment deposition and eliminates peripheral habitats important for YOY logperch (see previous section on channelization threats).

Road presence

Unlike the acute, local and physical nature of the impacts of road construction, the impact of an adjacent road on streams is primarily chronic, regional and chemical. Once construction ceases, most effects of road construction are corrected naturally through time; however, the effects of the presence of a road perpetuate themselves through time. Streams near roads accumulate chemical pollutants from automobile traffic which are released to streams by runoff. These pollutants accumulate in stream sediment and biota and are transported downstream resulting in both chronic and regional effects. Roads collect metals, oil and grease from automobile traffic and release these to streams during rainfall events. A study in the Roanoke River watershed found higher levels of lead and zinc in aquatic macroinvertebrates when traffic at upstream road crossings was heavy (Van Hassel et al. 1980). From the same study, Ney and Van Hassel (1983) reported fantail darters and blacknose dace had higher concentrations of lead, zinc, nickel and cadmium. The effects of heavy metals and pollutants on Roanoke logperch are unknown, but could be considered an additional threat (see Research Needs). Toxic chemical spills and deicing salt are more acute effects of road presence. Deicing salt is also a common chemical pollutant of streams, and toxic chemical spills occur frequently along bridges and highways and often enter stream ecosystems with negative consequences on biota (See section on threats from spills).

Urbanization

Roads are often constructed to encourage urban development and result in an increase in urbanization, whose impacts are difficult to quantify but potentially severe (see previous section on threats associated with urbanization).

Potential Impacts of the Proposed I-73 Corridor (summarized from Powell et al. 2002)

The proposed construction of Interstate 73 (I-73) addresses concerns set forth by Congress to improve movement of goods between states, encourage economic development, and address local safety needs. I-73 is considered a “high priority” by Congress and will connect Sault St. Marie, Michigan and Myrtle

Beach, South Carolina, including a 75 mile-long corridor through southwestern Virginia. A recent Natural Resources Technical Memorandum (NRTM), study prepared by the Virginia Department of Transportation (VDOT 2000) identified several potential routes for I-73 construction through the upper Roanoke, Pigg, and Smith River watersheds.

The impacts of the proposed I-73 corridor through the City of Roanoke on Roanoke logperch should be minimal. The current corridor follows the existing roads I-81 and I-58, following the present route of 220 through the community of Clearbrook, east of where 220 crosses the Blue Ridge Parkway. After passing through Clearbrook, the proposed path cuts north east again to presently unpaved ground in Franklin County. Because this corridor follows existing roads through the City of Roanoke, it will require minimal construction, thus lessening the potential for impacts. Another advantage of this route through the City of Roanoke is that it traverses areas that are already highly urbanized and developed, thus the danger from the impacts of future watershed urbanization is also minimized. Additionally, the proposed corridor is very near the downstream limit of Roanoke logperch in the upper Roanoke River, thus most Roanoke logperch in this region are located safely upstream of this corridor.

The population of Roanoke logperch in the Pigg River appears to be the most fragile and sensitive to the proposed interstate. The proposed corridor crosses the Pigg River 3km east of Rocky Mount, and thus the majority of Roanoke logperch in the Pigg River are downstream of the crossing, where they could be directly impacted by any chemical spills on highway or nearby road crossings or carelessness during construction. Watershed urbanization is also a substantial threat to Roanoke logperch in the Pigg River. Given the proximity of the area to the City of Roanoke and the reduced travel time provided by a new interstate, this area would likely develop quickly. Considering that only a small percentage of the Pigg River watershed is urban land, the biota of the Pigg River would be drastically harmed by the onset of urbanization. In contrast, the Smith River populations of logperch are well upstream of the proposed interstate and thus would likely be unimpacted.

Toxic Spills and Fish Kills

The effects of toxic spills on stream biota are typically acute and localized; however, in populations already weakened by restricted distributions and loss of habitat, they can be catastrophic. Toxic spills can originate accidentally or purposefully, from stationary storage facilities in agricultural or urban centers or, more frequently, from trucks transporting the material. It was difficult to obtain concrete information on the frequency and extent of recent chemical spills on Roanoke logperch populations in Virginia (see Research Needs); however, limited information indicates that spills are common and should be considered a persistent threat (Burkhead 1983; USFWS 1992; Wheeler et al. 2002).

Wheeler et al. (2002) describe the extent to which hazardous material transport could affect populations of Roanoke logperch. They state that hazardous materials are often moved by truck and, in 1982, composed almost a quarter of all domestic freight shipments. Accidental releases are frequent (e.g., 1738 occurrences from 1976-1984 in Virginia alone). US EPA reports an average of 10,000 accidental releases of 646,000 gallons of hazardous materials annually on U.S. highways between 1990 and 1994 (EPA 1996). The most severe of these incidents known to occur in the logperch range occurred in the Pigg River in 1975, when a discharge of copper sulfate from an accident in Rocky Mount (upstream of most of the logperch habitat in the Pigg River) caused a kill of an estimated 28,704 fish (many species, including logperch) over 36km of river (James 1979). The Pigg River is still the most likely population to be extirpated from a toxic spill. The reason for this is because the Pigg River population occurs over a very short length of river, has only one tributary locale known to contain logperch that could serve as a source for recolonization, and is located downstream of a major thoroughfare in Rocky Mount and the crossing of the proposed I-73. However, any Roanoke logperch downstream of any potential storage facilities for toxic chemicals or manure or major road crossings (e.g.,

Stony Creek tributary of the Nottoway River, Town Creek tributary of the Smith River) should be considered at risk of this potential threat. Even if these locales are not completely extirpated by a chemical spill, resulting genetic bottlenecks could reduce the adaptive potential of logperch populations, cause inbreeding depression, and decrease resilience to demographic and environmental stochasticity.

Removal of Woody Debris

Within the Fall Zone of the Nottoway River, woody debris, including large tree falls and snags, are a common sight (Rosenberger and Angermeier 2002). Roanoke logperch in this river are commonly observed in and around woody debris in low flow areas (Rosenberger and Angermeier 2002), which may serve as cover from predators and a source of food (Angermeier 1985). Wood removal practices and the deforestation of streambanks in streams and rivers of the Roanoke River basin has greatly reduced the availability of wood in these systems due to loss of riparian vegetation and intentional debris removal in urban areas (e.g., Roanoke River Flood Reduction project). It may be not only the silt cover but also the lack of woody debris in Roanoke River pools that reduce pool suitability for Roanoke logperch (see previous section on Habitat Use).

Small Dams and Movement Barriers

Small, lowhead dams and relict, unused dams are scattered throughout the range of Roanoke logperch and may form a barrier to logperch movement. One such dam can be found on the Pigg River, just downstream of the town of Rocky Mount and in the Smith River close to Martinsville. The extent to which these dams flood potential logperch habitat, prevent the connectivity of logperch populations, or restrict the distribution of logperch is unknown and deserves further investigation (see Research Needs). It is also possible that small

dams and movement barriers are trapping and retaining toxic materials and sediment that would otherwise be harming logperch.

Water Withdrawals

The extent to which water withdrawals affect logperch populations in the Roanoke River drainage is unknown and probably minimal. One water withdrawal project occurs in the Nottoway River; a titanium mining operation (Iluka Resources) in Dinwiddie and Sussex Counties withdraws water from the Nottoway River for their processing facility in Sussex County. However, withdrawal is minimal and strictly regulated (C. Saunders, personal communication); as long as withdrawal does not contribute to the drying of swift-water areas in the Nottoway River during the spring reproductive period, and other projects do not demand additional withdrawal, it is probably only a minor threat to the logperch in this system in drought years.

Section V. RESEARCH NEEDS

Although research in the last decade has dramatically increased our understanding of Roanoke logperch ecology, there are many avenues of research that would inform management for this species and add to our knowledge of their ecology and life history. Below are suggested avenues of research based on the author's expert opinion and evaluation of the literature, including suggestions from Roberts and Angermeier (2004). These are in no particular order of priority because the importance of the information from research depends on the management question.

1. Development of a spatially-explicit decision support model for managers that evaluates the relative cost/benefit of management or restoration activities in terms of cost and potential risks or benefits to logperch populations. Multiple threats to logperch populations that are more or less

problematic depending on the location of the threat and multiple potential management activities (including inaction) that would provide variable benefit depending on the location and cost of the activity make successful conservation and restoration of this species a complex and daunting task. A decision support model that explicitly takes into account these factors can be used to identify areas where conservation activities could be performed to maximize benefits at the least cost and identify areas where conflicts may occur or restoration activities would have minimal effect. In addition, this document recommends a watershed-level approach to conservation (see section on Management Recommendations) and a comprehensive, spatially-explicit decision support model would support that approach.

2. With an eye towards establishing a rigorous monitoring program, evaluation of sampling efficiency of Roanoke logperch for various sampling approaches (e.g., snorkeling and electrofishing), including habitat correlates of sampling efficiency (e.g., streamflow, temperature, and stream size) and differences between young-of-year and juveniles/ adults. Previous studies have shown that logperch can be marked with minimum risk of mortality with elastomer tags (Rosenberger and Angermeier 2002); therefore, establishing a 'known' population of logperch to resample using different techniques, though difficult, is possible.
3. A complete census of the use and availability of habitat for young-of-year logperch for all populations.
4. A better understanding of why logperch range extends to some areas, but not others. For example, is it due to habitat constraints, the legacy of past human impacts, or other reasons? Is this controlled at the reach or watershed scale? Could logperch persist in places where they aren't now but probably were historically?

5. Understanding the potential for logperch to recolonize extirpated areas and recover from disturbance begins with an understanding of their mobility. This understanding could arise through rigorously-designed mark-recapture studies together with an analysis of gene flow at the population level.
6. Genetic studies of known logperch populations can not only give an indication of gene flow and mobility, but also the relative density and strength of these populations for future monitoring purposes. Nuclear markers with a high degree of variability would be most useful for these purposes (e.g. microsatellites, MHC complexes). From these data, there is potential to obtain information on: 1) population structure of the species; 2) historical and current population size; 3) degree to which populations are connected by dispersal; and 4) the amount of movement of physical space involved in completing the logperch life-cycle, though other means would be needed to confirm these results.
7. A better understanding of watershed-scale correlates of Roanoke logperch presence and year-class strength (e.g., summer stream flow), with an eye towards understanding what stochastic and deterministic variables regulate logperch population dynamics. These can be related to potentially important local features of habitat, such as availability of young-of-year rearing and feeding habitat through the growing season or the flushing of silt and sediment. Studies on the Roanoke River indicate that stochastic factors, such as springtime stream flow, could be very important determinates of year-to-year variability in logperch population densities. This hypothesis can be contrasted against the hypothesis that rearing and/or feeding habitat are limiting logperch densities. If habitat is not what is limiting for these populations, then habitat restoration will have limited effect on increasing logperch population densities and/or range and achieving recovery objectives.

8. For all logperch populations, a better understanding of logperch mortality rates and causes at different life stages (e.g., predation from non-native predators, starvation, high flows) and what habitat choices may mitigate those sources of mortality.
9. Population-specific descriptions of the reproductive cycle and reproductive habitat use of Roanoke logperch. Both thermal and flow conditions, which differ among rivers, may be important cues for the onset of logperch reproductive behavior.
10. A better evaluation of how existing and proposed road projects, industrial centers, or storage facilities will increase the risk of localized or large-scale extirpation of logperch populations through toxic chemical spills. This evaluation should include an assessment of potential source populations of Roanoke logperch should a spill occur and an understanding of major routes for transporting potentially toxic material. This analysis will allow managers to direct their attention to the most high priority areas for prevention of spills.
11. An inventory of movement barriers in the form of poorly maintained culverts or unused power or lowhead dams throughout the range of logperch that could be removed to improve the connectivity of populations. This study should also include an assessment if lowhead dams are protecting logperch by holding back damaging sediment or toxins trapped in sediment and should be ranked by isolating effect, economic value, and potential for removal.
12. A better understanding of the frequency and extent of effects of chemical pollutants from urban runoff on logperch populations. Urbanization is dramatically increasing over the entire range of Roanoke logperch. This is a growing threat that is not well understood.

13. A better understanding of how riparian condition affects sediment loading in rivers and how much buffer is required to reduce the amount of sediment entering streams containing Roanoke logperch.

Section VI. MANAGEMENT AND RECOVERY RECOMMENDATIONS

Management Approach

Protection of a species based on a single life stage, such as the adult stage, or protection that ignores potential for spatial variation in demographic processes over multiple scales is naturally incomplete. Each size class of Roanoke logperch selects particular habitat configurations, and the species uses a wide range of habitats over its ontogeny. Successful conservation of this species will therefore involve the preservation of the ecological processes that maintain the connected habitat mosaics required over logperch life history. Specific attention should be paid to the creation of and access to mesohabitat types such as backwaters and clean pools as well as relatively silt-free microhabitats with low to intermediate water velocities.

Our understanding of Roanoke logperch microhabitat use indicates that loosely embedded sediment free of heavy silt cover is critical growing habitat for this endangered species. The peculiar feeding habits of logperch necessitate the availability of loosely embedded gravel that can be flipped by a small fish to reveal aquatic insects. Management programs that enhance the natural streamflow of occupied rivers should include protection of the streambank from agricultural and construction practices that contribute silt loads. Scouring flow during natural flood events should also enhance habitat through removal of small sediments, particularly in backwaters that are rarely exposed to scouring water velocities. Historic and ongoing floodplain development, especially in the Roanoke River drainage, can threaten logperch habitat, particularly backwaters and shorelines that appear to be important for

YOY logperch. However, it seems evident that a natural flow regime will not be sufficient to provide needed habitats if sediment loading remains or becomes elevated in systems occupied by logperch.

In addition to protecting logperch from threats that affect populations incrementally and slowly, it will be important to protect Roanoke logperch from catastrophic loss due to water projects and chemical spills. A spatial understanding of how these threats are distributed over the landscape and may differentially affect fish populations will be necessary to effectively manage these threats (see Research Needs).

All of the information contained in this document suggests that a piecemeal approach to conservation will be ineffective if recovery of this species is to be achieved. Evidence that Roanoke logperch requires a low-silt, complex habitat mosaic over multiple spatial scales indicates that reach-specific management approaches will not ensure the recovery and persistence of this species. In addition, the extent to which listed threats affect logperch differs from location to location and from population to population. Based on this, I recommend a range-wide watershed-level approach to logperch conservation and recovery that addresses all threats in a spatially explicit manner. For the Roanoke drainage, management could put particular emphasis on sediment loading and preserving natural flow regimes that provide ephemeral, seasonal, and persistent types of habitat required over logperch ontogeny. It could also concentrate on increasing the population connectivity.

For the Nottoway River, emphasis should be placed on monitoring, preservation, and prevention of catastrophic events, as this unique system shows signs of increasing health and a strong logperch population. Emphasis could be placed on protecting potential limiting habitats, such as swift water reproductive habitat during the spring spawning season by enacting more stringent water withdrawal regulations.

Proposed Recovery Objectives

Proposed Recovery Objective 1: Maintain and increase the health and vigor of present populations through a watershed-level conservation approach that addresses sediment loading and preserves ecological processes that provide ephemeral, seasonal, and persistent types of habitat required over logperch ontogeny. Avoiding a piecemeal conservation approach will reduce threats from urban sprawl and industrial development. Although potentially degrading agricultural activity has the potential to adversely affect logperch throughout its range and may be responsible for historical declines, three areas are particularly degraded by agricultural activities and may be good areas for stream restoration projects and projects to improve agricultural practices: 1) the North Fork of the Roanoke River; 2) the Pigg River upstream of the town of Rocky Mount; and 3) the Smith River upstream of Philpott Reservoir. Additional restoration work in the Town Creek population of Roanoke logperch could also increase the value of this locale for logperch. Areas that help maintain existing habitat for logperch should be aggressively preserved and maintained.

Proposed Recovery Objective 2: Expand the present range of Roanoke logperch by identifying unoccupied areas with suitable habitat within its previous range and reintroducing logperch into those locations with consideration for genetic and local adaptation consequences as well as the capacity of the receiving habitat for maintaining a persistent population of Roanoke logperch. If genetic considerations outweigh the benefits of the range increases, this objective may need to be abandoned. In addition, a place should not be identified as 'unoccupied' unless extensively sampled using validated techniques so that managers can be at least 95% confident that no existing logperch can be found in those sites or in nearby sites that could seed natural recolonization.

Proposed Recovery Objective 3: Increase connectivity of Roanoke logperch populations by identifying major and minor artificial movement barriers and eliminating them when feasible. This should occur only with consideration for potential for opening pathways of dispersal for nonnative species like rock bass, release of toxic or fine sediments, and an understanding of whether these dams are protecting downstream logperch from excessive sedimentation upstream.

Proposed Recovery Objective 4: Prevent and reduce the risk of catastrophic extirpation from large spills through maintenance and improvement of present highway and road-crossings and enforcement and educational displays at likely dumping locations. Insure population maintenance and recolonization potential by increasing population connectedness, maintaining and monitoring peripheral locales that could be source populations in the event of a catastrophic spill (e.g., tributary populations), and considering potential loss of populations or locales through spills for evaluation of any proposed bridge or highway construction within the range of the Roanoke logperch.

Proposed Recovery Benchmarks

Benchmarks have limited meaning and use unless there is a sound basis for the present condition of logperch populations and intensive and validated monitoring. Assuming that sound data are available, this document proposes the following new benchmarks to be established in order for logperch to be downlisted to 'Threatened' status under the Endangered Species Act:

- 1) A stable or increasing trend in logperch population densities in indicator sites located at both central and peripheral locales for all 6 populations of logperch over a 20-year period (3 logperch generations).
- 2) A stable or increasing trend in the range extent of all six populations over a 20-year period.

- 3) A stable or increasing trend in overall population strength (for definition see below under ‘Proposed Recovery Practices’) for all six populations over a 20-year period.
- 4) An increasing trend in the overall strength of Roanoke logperch populations in at least 3 of the defined populations (recommended benchmark = 25%; for definition on strength, see below under ‘Proposed Recovery Practices’)
- 5) A stable or increasing trend in the continuity of all six populations. This will involve the removal of movement barriers, improved dam release practices to improve the continuity of logperch habitat, and restoration of stream reaches that fragment populations by creating long reaches of unsuitable logperch habitat.
- 6) A stable or increasing trend in the length of occupied stream channels with high quality logperch habitat, e.g. habitat that is silt-free and suitable for all life stages of Roanoke logperch.
- 7) A stable or declining trend in known threats to Roanoke logperch for all 6 populations.

Proposed Recovery Practices:

- 1) Establish a defensible metric for logperch population and locale strength that could be used for regulatory purposes. The research proposed above may inform or alter this metric. Based on present available research, I propose the following information be included in such a metric:
 - a. Age 1+ density along several indicators along the length of river occupied. YOY densities can be patchy in time and space and are less reliably captured; however, densities should be monitored to obtain information on the spatial and temporal variability of this life stage.
 - b. Length of river occupied by logperch (i.e., distributional extent or range)

- c. Number of potential movement barriers
 - d. % of occupied stream length with high quality habitat for each life stage of logperch
 - e. Number of locales along the length of stream that can act as sources of recolonization should stream lengths be extirpated due to catastrophic spills
 - f. Length of river upstream and downstream of known threats
 - g. Weight of threat based on degree of risk to logperch populations
- 2) Establish an intensive and defensible monitoring protocol to monitor logperch population strength based on this metric using validated methods and multiple remote and site-based approaches.
 - 3) Determine the amount of sediment loading coming from different threats and reduce sediment loading by at least 50% through restoration activity.
 - 4) In lieu of designating critical habitat, create a GIS layer of all threats in each watershed (e.g., toxins, urban development, agricultural inputs). Designate Roanoke logperch protected habitat, and, within these protected areas, use restrictive zoning and wide riparian buffers to protect logperch habitat.
 - 5) Within Roanoke logperch protected habitat, establish minimum riparian buffers necessary to stabilize stream banks and reduce silt loads. A minimum of 20 meters should be set until research better establishes what the width of buffer should be in different areas containing logperch.
 - 6) Establish a maximum impervious surface below the threshold required to maintain a healthy watershed (10%; Wheeler et al. 2002). New construction must undergo strict regulation and take place with mitigation measures to reduce the impact of increased impervious surfaces and other effects of urbanization.
 - 7) Any road, highway, bridge, or ramp construction or maintenance should include an assessment of the risk to populations through spills. Retention ponds at likely spill locations should be constructed to reduce risk.

Monitoring Recommendations

Monitoring of logperch densities should occur on two facets: 1) density of logperch populations in *both* population strongholds (e.g., upper Roanoke River) and in peripheral areas (edges of their ranges, e.g., North Fork Roanoke River, close to Leesville Reservoir in the Pigg River). Information on other species suggests that population declines are often first detected away from the 'core areas' (Isaak and Thurow 2006), and, instead of declining uniformly, species will remain in similar densities in population strongholds and decline only in the peripheral areas with suboptimal habitats. If monitoring for logperch is concentrated only in its strongholds, it may not work for detecting population declines. Additional monitoring should occur to confirm and monitor the limits of logperch ranges, which appear to be increasing with increasing sampling effort (Lahey and Angermeier 2006b).

Care should be taken in both cases to use validated sampling approaches (see Research Needs section). Monitors should keep in mind that validation involves more than simply using consistent protocols from year to year. Creating comparable data sets involves collecting data that has clear meaning in terms of both precision and accuracy relative to the unknown true population parameters of interest. Using a common protocol is an important step in standardization but cannot guarantee common, comparable, or defensible results. Assessments of measurement error can require additional resources and are often logistically very time-consuming and require great effort. However, validation of sampling methods is a short-term investment compared to the long term benefits of increased confidence in data quality and the ability to compare data using a variety of methods and approaches with known precision and accuracy. Such investments are well worthwhile in terms of the value of information and the implications for sound management decisions.

A clear understanding of sampling efficiency can be related both to the detectability of a species and the reliability of abundance estimators. For

example, if one has a reasonable estimate of sampling efficiency, then one can estimate how much effort it will take to detect the presence of Roanoke logperch in a particular site, and how much weight should be placed on absence data. False absences are likely to be common when sampling logperch because of the likely low sampling efficiency of this species (Lahey and Angermeier 2006a). Absences should be treated with the proper amount of skepticism until sampling efficiencies and what affects sampling efficiency is better understood.

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Appendix I. 5-YEAR REVIEW.

Template of the 5-year review of endangered species, filled in with information directly quoted from this document and some additional information required by this template. All additions to this template are highlighted in blue using Microsoft Sans Serif font.

5-YEAR REVIEW FOR THE ROANOKE LOGPERCH *Percina rex* DRAFT TEMPLATE FOR FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES

Introduction

The template is designed to encourage the use of summative documents when available and to focus the reviewer's efforts on providing summary statements that document the deliberative process. The result should not be an exhaustive report; rather, the review should be a concise and well-researched document in which the writing reflects the decision making process (i.e. critical writing). Because this template records a deliberative process, the reviewer is asked to complete the template in order. Guidance on conducting a 5-year review is available in the Five-year Review Guidance. Note that the term "species" is used throughout this document as it is defined in Section 3 of the ESA (i.e., a species, subspecies, or a distinct population segment). Ensure that any detailed information that might imperil a species (e.g. locations of narrow endemics) or identify ownership of private lands does not appear in this review.

For FWS, the information requested regarding species priority number, species status (declining, stable, improving, uncertain), and percent recovery achieved is available from TESS. Provide updated information and any corrections so that changes can be made in TESS.

For further guidance on determining the species recovery priority number should a change be considered warranted as a result of this review, refer to *55 FR 24296* (NOAA) or *48 FR 43098* (FWS) and to Chapter 3 of the *Draft Recovery Planning Guidance* ("Preliminary Recovery Strategy") available on the sii (for FWS).

[The purpose of the 5-Year Review process is not to revisit the original listing or to produce a new listing document. Rather, the purpose is to identify and analyze new information in the comparison to the last status review to determine whether a change in a species classification is warranted. If through the 5-Year Review, we determine that there is sufficient evidence to warrant reclassification, a proposed rule would be prepared according to listing priority number.]

5-YEAR REVIEW

Species reviewed: [Roanoke logperch / *Percina rex*](#)

Date completed:

METHODOLOGY USED TO COMPLETE THIS 5-YEAR REVIEW

Briefly provide information that describes the method or process used in conducting this review. For example, provide information regarding whether the review was a team or an individual effort, whether a certain portion of the review was contracted out, whether certain documents and data were relied on more heavily than others, whether a structured decision-making process was used, whether the analysis of data was peer reviewed, etc.

GENERAL INFORMATION

FR Notice announcing initiation of this review: *Provide citation for notice that announces the active review of the species*

Lead Region: *Also provide contact name(s) and phone number(s)*

Lead Field Office: *Also provide contact name(s) and phone number(s)*

Name of Reviewer(s): *Provide name(s) and phone number(s)*

Cooperating Field Office(s): *Also provide contact name(s) and phone number(s)*

Cooperating Region(s): *Also provide contact names(s) and phone number(s)*

BACKGROUND

Existing Recovery Plan or Outline: *Provide the name of plan or outline, date issued, and revision history.*

Name of Plan: [USFWS 1992. Roanoke logperch \(*Percina rex*\) Recovery Plan. Newton Corner, MA. 34pp.](#)

Date issued: [March 20, 1992](#)

Species Existing Recovery Priority Number: (i.e. 1 – 18 or 1C – 18C) *Summarize rationale and cite original justification, if available.*

Listing History

Original Listing: *Provide FR notice, date, entity listed (i.e., species, subspecies, DPS), and classification as threatened or endangered. If listed as a DPS, note whether it was listed prior to the DPS policy of February 7, 1996.*

FR notice: 54 FR 34464; Species Listed: *Percina rex*; Classification: endangered
Date listed: August 18, 1989

Revised Listing: *If applicable, provide FR notice, date, entity listed (i.e., species, subspecies, DPS), classification as threatened or endangered, and indication if the revision was as a result of a petition, etc.*

Associated Actions: *If applicable, identify any experimental populations, similarity of appearance cases, protective regulations, 4(d) rules, or critical habitat.*

Critical habitat has not been designated for this species. Populations are limited in number, size, and range; therefore, none of them should be considered 'dispensable' or outside of the critical designation.

Review History: *List all previously conducted reviews (e.g., status review(s), 5-year review(s), candidate species status review(s), date(s), results, and any resulting action(s)).*

Most recent Species Status as reported in the Biennial Recovery Report to Congress:

Species Status: (i.e., I, D, S, etc.)

Recovery Achieved: (i.e., 1, 2, 3, or 4; FWS only)

Reference Point Documents: *List the document(s) that individually or together represent the most recent comprehensive analyses of the species. These documents should serve as a summary of the current status of the species and threats in relation to that in the most recent status review. [See "Further Explanation of Reference Point Documents"]*

See attached document, "An update to the Roanoke Logperch Recovery Plan" and literature cited. Prepared by Amanda E. Rosenberger (contract work).

REVIEW ANALYSIS

- I. **DPS Policy: Is the species under review listed as a Distinct Population Segment (DPS)?**
 - A. **Application of the 1996 Distinct Population Segment (DPS) policy to DPS-listings made prior to enactment of the policy: Was the DPS listed prior to 1996?**

1. **Prior to this 5-year review, was the DPS classification reviewed to ensure it meets the 1996 policy standards?**
2. **Does the original listing meet the DPS policy with regards to the discreteness and significance elements of the 1996 policy?**

B. New Information on Application of the DPS policy: Is there relevant new information with respect to the appropriate application of the DPS policy to the listed species under review?

II. Recovery Criteria: Does the species have a recovery plan?

Yes.

A. Recovery criteria: – does the recovery plan contain downlisting, delisting, and/or uplisting criteria?

Yes. Criteria for downlisting the Roanoke logperch are:

- 1) all four populations are stable or expanding and protected from foreseeable threats;
- 2) abundance and/or range size is increased for the Roanoke River population and at least two other populations.

B. Do the recovery criteria for delisting, downlisting, and/or uplisting criteria address both biological factors and threats to the species?

No. They are too general and lack appropriate or defensible benchmarks.

III. Current Species Status and New Information:

A. Improved Analyses: Has application of any improved analytic methods resulted in relevant new information?

Yes. See attached document “Update to the Logperch Recovery Plan” and associated literature cited. Below is a summary of this document:

The Roanoke logperch (*Percina rex*) was listed as an endangered species on August 18, 1989 (54 FR 34464). This species is endemic to Virginia and its range is limited to 6 disparate populations within Virginia’s Roanoke and Chowan river drainages. Within the Roanoke drainage, Roanoke logperch are found in the Roanoke River drainage upstream of Smith Mountain Lake, the Roanoke River drainage downstream of Leesville Reservoir, the Pigg River drainage, and the Smith River drainage. Within the Chowan system, a population of Roanoke logperch can be found in the Nottoway River drainage along the fall zone between the Piedmont and Coastal Plain physiographic provinces. All of the existing populations of Roanoke logperch are threatened by road

projects, water projects, catastrophic spills, and siltation from agricultural runoff. Populations in the Roanoke River drainage are further threatened by urbanization and industrial development. Recent studies of the distribution and habitat use of Roanoke logperch suggest that this species is subject to riverwide stochastic processes and has strict microhabitat requirements. The distribution of habitat types and pathways of dispersal are critical for maintenance of healthy populations. Along with a stronger monitoring program, this document proposes a multi-tiered approach for recovery of the Roanoke logperch based on literature review and expert opinion.

B. Species Status and Baseline

1. New Information: Biology and Habitat:

- a. 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?

Densities and Abundance

Regulatory processes often require information on absolute abundance of endangered animals when assessing recovery or impact. Unfortunately, obtaining reliable information on logperch densities and total abundance is extremely difficult and may have limited meaning for this species. Logperch are a sparsely and patchily distributed, benthic, and cryptic species, all of which make a comprehensive, reliable census of logperch abundance among and within rivers extremely difficult. Recent intensive surveys indicate that at sites where logperch are sparse, they are not captured in most electrofishing passes or in most riffle-runs (Lahey and Angermeier 2006). Snorkeling using a distance-weighted model as well as electrofishing are reasonable approaches for obtaining logperch densities at the site-scale (Ensign et al. 1995); however, a validation study that compares estimates of logperch densities against a known, unbiased baseline estimate of logperch abundance has not yet been completed (see Research Needs section). An examination of density estimates among sites and years in a long-term data set suggests that high streamflows that increase water depth and velocity could lower electrofishing capture efficiency of Roanoke logperch (Roberts and Angermeier 2004). Other characteristics of the habitat such as water conductivity, turbidity, vegetation, and substrate composition could also affect sampling efficiency using electrofishing or snorkeling; however, little is understood about the relative effects of any of these habitat characteristics on sampling efficiency for Roanoke logperch. Finally, most surveys of logperch target habitats preferred by larger individuals, and capture of YOY using electrofishing techniques is rare (Roberts and Angermeier 2006). Low capture of YOY using electrofishing gear suggests that Roanoke logperch do not recruit appreciably to electrofishing sampling gear until at least their first fall (Roberts and Angermeier 2006).

A long-term (8-year) data set collected in the Roanoke River as part of pre-construction monitoring for the Roanoke River Flood Reduction project suggests a great deal of seasonal and annual temporal variability in logperch densities, even within sites that remain relatively stable in habitat availability (Roberts and Angermeier 2006). High Age 1+ density and high Age-0 density sites are spatially disconnected, suggesting logperch have a high capacity for dispersal, either through larval drift or Age 1+ movements (Roberts and Angermeier 2004). These multiple lines of evidence suggest that temporal variability in logperch densities within sites may be driven by river-wide stochastic phenomena such as stream flow conditions, but this is not well understood (see Research Needs section). Spatial, among-site variability in logperch densities can also be high (Roberts and Angermeier 2006; Rosenberger and Angermeier 2002) and may be partially related to differences among sites in the availability of suitable microhabitat for summer feeding (Roberts and Angermeier 2004; Lahey and Angermeier 2006c) and partially related to longitudinal patterns within the stream (Roberts and Angermeier 2006). All of these factors suggest that power to detect impact or a significant decline in logperch abundances, even when using single sites as 'indicator sites', is extremely low and will require an extensive, baseline understanding of logperch densities, sustained, long-term sampling for detecting impact, and a better understanding of what natural factors contribute to year-class strength of Roanoke logperch (Roberts and Angermeier 2006).

The following sections are a description of logperch density in each of its populations in a relative rather than an absolute sense, as absolute numbers would be suspect and have limited meaning. It is unknown whether logperch are at maximum population densities that could be expected (logperch may naturally occur at low densities, as they are typically found) at any of these locations, since researchers are still not clear whether or not logperch are presently limited by demography, reach-wide environmental conditions such as stream flow, or growing or rearing habitat.

Upper Roanoke River

The largest population of Roanoke logperch is found in the upper Roanoke River. Several factors contribute to the overall strength of this population: 1) comparable or higher densities of logperch at monitored sites in the Roanoke River relative to comparable sites in the Nottoway, Pigg, and Smith rivers; 2) the longest stretch of contiguous river kilometers occupied by Roanoke logperch; 3) presence of logperch in multiple river tributaries, including the North and South forks of the Roanoke River and Tinker Creek, all of which could act as sources in the event of an extirpation of the species along a length of the occupied mainstem river (Ensign et al. 1997).

Middle Roanoke River

Goose Creek and the nearby Little and Big Otter rivers appear to be sparsely and patchily populated with logperch but have not yet been sampled extensively

enough to determine relative population densities (Lahey and Angermeier 2006b).

Pigg River

Although surveys of the Pigg River in the past have indicated that logperch are rare in this system (James 1979, Jenkins and Burkhead 1993), more recent surveys indicate that Age 1+ logperch are found at only slightly lower densities in occupied sites in the Pigg River than in the Roanoke River (Lahey and Angermeier 2006a). However, young-of-year are rarely observed in the Pigg River (Rosenberger and Angermeier 2002). Extremely low densities and the rarity of logperch in past surveys of the Pigg River may be due to a chemical spill during 1975 in the middle portion of the Pigg River at Rocky Mount, Virginia that caused a catastrophic fish kill that extended 36 kilometers downstream (James 1979). Although logperch did recolonize previously occupied areas in the Roanoke River drainage within two years of a massive manure spill (Ensign et al. 1997), most of the length of the Pigg River known to be occupied by logperch was affected by the 1975 spill, and only a small stretch of river and a small length of occupied river could have acted as a source for recolonization, which may have slowed the recovery process.

Smith River Populations

Roanoke logperch in the Smith River are separated into two populations by Philpott Reservoir and may be further fragmented by unsuitable habitat downstream due to dam operation. In the Smith River population upstream of the reservoir, a single site surveyed had comparable logperch densities to sites in the Roanoke River; remaining sites contained logperch at comparable densities to the Pigg River (Lahey and Angermeier 2006c; J. Roberts personal observation) or only single or no logperch (A. Rosenberger, personal observation). Downstream of the dam, logperch are found at low densities in Town Creek (D. Orth, M. Anderson, and S. Smith, personal communication) and in the Smith River 9-39 kilometers below the dam, where operations have less effect on river habitat (Orth 2001; S. Smith personal communication).

Nottoway River

Previous discussions of logperch densities assert that the highest densities of Roanoke logperch can be found in the Roanoke River (Jenkins and Burkhead 1993); however, analysis and trends suggest that the population in the Nottoway River, although existing along a shorter length of river, may occur at equal or greater densities (Rosenberger and Angermeier 2002). Further, large YOY logperch have been observed at high densities in the Nottoway River (Rosenberger and Angermeier 2002). It is possible that the relatively pristine condition of low velocity habitats that YOY prefer (Burkhead 1983; Rosenberger and Angermeier 2002) contribute to strong juvenile production in the Nottoway River. In tributaries of the Nottoway River, logperch in Stony Creek probably occur at densities comparable to the Pigg River (A. Rosenberger personal observation); logperch in Butterwood, Sappony, and Waqua creeks are probably sparsely distributed at low densities, but these streams are not well

surveyed or understood (Lahey and Angermeier 2006b). High densities of Age 1+ individuals and YOY in the mainstem river, a tributary locale with comparable densities, pristine conditions in low-velocity habitats, and a lack of large dams indicate that the Nottoway River population is both strong and unique. However, the relatively short length of occupied river in this system make it vulnerable to large spills or any water projects that could impound swift-water areas or fragment the population. In addition, if the population in the entire Nottoway drainage (including tributaries) is extirpated, it cannot be recolonized by adjacent, similar populations.

Trends in populations: increasing, steady, or declining?

Current criteria for downlisting the Roanoke logperch from Endangered to Threatened are: 1) all populations are stable or expanding and protected from foreseeable threats (total number “populations” according to this document = 6); 2) abundance and/or range size is increased for the Roanoke River population and at least two other populations (USFWS 1992).

The present understanding of the logperch range and densities indicate that all populations extend further and are denser than previously assumed (Simonson and Neves 1986; Burkhead 1983). Populations in the upper Roanoke and Nottoway show comparably high densities of logperch (Rosenberger and Angermeier 2002) and high genetic diversity compared to other populations (George and Mayden 2003). However, a poor understanding of the baseline abundances of logperch at the time of listing makes it difficult to ascertain if the logperch populations are presently increasing, steady, or declining. All populations have probably decreased in range size and potentially densities over the past 200 years due to loss of habitat from widespread siltation from human development and agriculture and the creation of large reservoirs. The presence of a small, isolated population in the Smith River suggests that this species can persist over decades in very small areas; however, small populations can still be particularly vulnerable to environmental and demographic fluctuations over the long term.

Upper Roanoke River

The population of Roanoke logperch in the upper Roanoke River is probably the largest, most important population in this species' range as well as the most studied. It occupies the longest range of river kilometers and has a number of tributaries that contain logperch. Long-term data sets on logperch from the Roanoke River are valuable for understanding logperch population sizes, structure, and dynamics (Roberts and Angermeier 2006). Recent data indicates that this population is dynamic, but shows no signs of decline (Roberts and Angermeier 2006). However, all of the known threats to logperch (see Threats section) exist in the Roanoke River drainage and show no signs of disappearing or declining. Therefore, this population should still be considered vulnerable. Age-1+ habitat does not appear to be limiting population density at current levels (Roberts and Angermeier 2006). However,

a loss of habitat from multiple projects in the region could exceed an unknown threshold and result in an eventual decline in logperch population densities (J. Roberts, personal communication).

Middle Roanoke River

Discovery of logperch in the Big and Little Otter rivers and Goose Creek locales are expansions of the known range of this species since it was listed; however, they are not well studied and it is unknown whether these populations are increasing, declining, or stable (Lahey and Angermeier 2006b).

Pigg River

The Pigg River population is showing signs of increasing in size and range since the large spill occurred in the system in 1975 (James 1979; Rosenberger and Angermeier 2002; Lahey and Angermeier 2006b). However, the population still remains small and isolated from the Roanoke River population and shows signs of lower genetic diversity (George and Mayden 2003), which may make it vulnerable to inbreeding or extirpation from demographic or environmental stochasticity. Proposed road projects (I-73) and the existing road crossing in Rocky Mount make this population vulnerable to a variety of threats, particularly road development, urbanization, and chemical spills (see Threats section).

Smith River populations

The Smith River populations are vulnerable due to fragmentation from Philpott dam and small size, but its population size probably remains stable since the time this species was listed. The continuing operation of Philpott Dam and continued siltation from upstream agriculture indicates that threats have not been eliminated or declined for this population. An impoundment named “Charity Dam” was once proposed for the Smith River upstream of Philpott Reservoir (Jenkins and Burkhead 1993), but the project has not moved forward in recent years. If the project is resurrected and completed, it could pose additional threat and extirpate logperch upstream of Philpott Dam.

Nottoway River

The Nottoway River population was once considered highly vulnerable due to widespread siltation from agricultural and forestry activity in its watershed (USFWS 1992). Recent surveys indicate that these threats have declined and the population is increasing in range and in density (Rosenberger and Angermeier 2002). If agricultural and forestry activities in the area continue along their current trajectory of minimal siltation and avoidance of riparian areas along the fall zone of the Nottoway River, this population should remain stable and may continue to increase if habitat is currently limiting this population. Because the population occurs over a relatively small length of the river and because of the potential limitation of swift-water reproductive habitat (see habitat requirements below), this population is probably most vulnerable to any projects that withdraw water during the reproductive season to the point

that swift-water habitat is eliminated. Dam construction could also impound the same habitats and fragment the population.

- b. genetics, genetic variation, or trends in genetic variation (e.g. loss of genetic variation, genetic drift, inbreeding, etc.)?

A recent genetic study of logperch populations (George and Mayden 2003) suggests low genetic divergence between the Roanoke, Pigg, Smith, and Nottoway River populations of logperch, supporting the notion that the reduction in range occurred within the last 200 years with agricultural expansion in the region. The highest genetic diversity is in the Roanoke and Nottoway river populations; the Pigg and Smith river populations show signs of low genetic diversity and potential for inbreeding depression or genetic drift (George and Mayden 2003). However, additional genetic information is needed to confirm these results or to reveal small-scale genetic structuring in logperch populations.

- c. taxonomic classification or changes in nomenclature?

No changes in nomenclature since listing.

- d. 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.)?

Known Present Distribution

Knowledge of the distribution of Roanoke logperch has grown since it was first listed as endangered in 1989, but its geographic range remains small (Lahey and Angermeier 2006a). It is hypothesized that Roanoke logperch historically occurred contiguously throughout the Roanoke and Chowan watersheds prior to European settlement of Virginia. The species is now disjunctly distributed in the Roanoke Watershed in the Roanoke, Pigg, and Smith river drainages. It is also present in the Chowan Watershed in the Nottoway River drainage. Logperch within each of these river drainages can be further subdivided among various tributaries and mainstem sections that are isolated from one another to varying degrees by man-made barriers and/or reaches of unsuitable habitat. The resulting population structure of this species is complex, and, to varying degrees, artificial, thus complicating determination of the number of "populations" for describing logperch ecology as well as setting recovery objectives and assessing whether these goals have been met.

For purposes of this document, we parsimoniously treat occupied areas not separated by a major dam as comprising a "population," making for 6 total

populations of Roanoke logperch: (1) the upper Roanoke River drainage upstream of Smith Mountain Reservoir; (2) the middle Roanoke River drainage downstream of Leesville Reservoir; (3) the Pigg River drainage; (4) the Smith River drainage upstream of Philpott Reservoir; (5) the Smith River drainage downstream of Philpott Reservoir; and (6) the Nottoway River drainage.

Localities within these 6 major populations may be isolated to a varying extent by man-made barriers and/or unsuitable habitat. Designation as a separate population will require further investigation (e.g., genetic analysis). Candidate localities include: the Smith River downstream of Martinsville Dam, Town Creek, Goose Creek, and the Big and Little Otter rivers.

Unoccupied but suitable locations

Potential Roanoke logperch habitat within its probable range prior to human development of the region have been identified in the Dan, Mayo, Blackwater, Falling, and Meherrin river drainages; however, surveys of potential habitat have not revealed any logperch at these localities (Lahey and Angermeier 2006b). This does not necessarily mean that logperch are not present at these locations; low sampling efficiencies means that the detectability of this species is very low without extensive and intensive effort and the likelihood of false absences high when logperch are present at low densities.

Upper Roanoke River

The upper Roanoke River population of logperch is relatively large and continuously distributed throughout the North Fork, South Fork and mainstem Roanoke River in and near the City of Roanoke. A detailed report of logperch distribution in the North Fork Roanoke River indicates that logperch can extend 35.6km upstream of the confluence of the North and South Forks with the mainstem River (Ferguson et al. 1994). Logperch have also been found in Mason and Tinker creeks, tributaries to the Roanoke River (Burkhead 1983; Simonson and Neves 1986); however, recent surveys in Mason Creek have revealed no logperch. Urban development or other related causes in the creek watershed may have extirpated logperch from this locality, or effort may have been insufficient for detection (Lahey and Angermeier 2006a). Niagara Dam in Roanoke County is generally considered the downstream extent of logperch in the upper Roanoke River (Lahey and Angermeier 2006b); however, several isolated specimens of logperch have been captured in the Niagara Dam tailwater before it enters Smith Mountain Lake (B. LaRoche, personal communication). Isolated specimens of logperch were also found in Beaverdam Creek Cove and Moorsman's Cove of Smith Mountain Reservoir, Bedford County, and in the Roanoke (Staunton) River, Campbell County, near Brookneal Hatchery (Miller and Morton 2000).

Middle Roanoke River

In the middle Roanoke River drainage, logperch have been captured in Goose Creek, Bedford County, close to the Huddleston Gauging Station (Lahey and Angermeier 2006b). Goose Creek enters the Roanoke River 120 river

kilometers downstream of the downstream extent of the upper Roanoke River population. Logperch have also been found in the Little Otter River, a tributary of Big Otter River, which enters the Roanoke River downstream of the Goose Creek confluence (Lahey and Angermeier 2006b) and in the Big Otter River close to its confluence with the Little Otter River (J. Roberts, personal communication). The close proximity of the tributaries' confluences with the Roanoke River implies a potential connection between the localities and the potential for logperch to be in the mainstem river and other tributary locations.

Pigg River

The Pigg River also supports a population of Roanoke logperch (Rosenberger and Angermeier 2002) along with a rich assemblage of native species (Lahey and Angermeier 2006b). This population extends slightly upstream of the City of Rocky Mount and likely continues as far downstream as its confluence with Leesville Reservoir. Only one of its tributaries, Big Chestnut Creek, is known to contain logperch (Lahey and Angermeier 2006b).

Smith River populations

A population of logperch, along with a rich native assemblage, is found in the mainstem Smith River upstream of Philpott Dam (Lahey and Angermeier 2006c). Some of the larger tributaries of the Smith River upstream of the dam may also contain logperch, such as Rockcastle Creek (S. Smith personal communication); however, this population has not been extensively studied.

Logperch have been captured 8.9-39 river kilometers below Philpott dam (Orth 2001; S. Smith, personal communication); density appears to increase with distance from the dam (Orth 2001). Hydropeaking and cold water from dam release in the summer months likely restrict logperch from persisting closer to Philpott Dam within the mainstem river. Logperch have also been observed downstream of Martinsville Dam on the Smith River almost to the state border with North Carolina (S. Smith, personal communication). It is possible that this logperch population extends into North Carolina, but that is unknown (S. Smith, personal communication)

Logperch can also be found in Town Creek, which enters the Smith River immediately downstream of Philpott Reservoir (Orth, Anderson, and Smith, personal communication). Although there are no major movement barriers between the Town Creek and the lower Smith River logperch populations, a large stretch of unsuitable habitat due to dam release may isolate Town Creek from likely recolonization should extirpation of this locality occur. It is possible, however, that individuals from Town Creek could be swept downstream and supplement the Smith River population below Philpott Reservoir. Movement upstream in the Smith River into Town Creek is also possible, but daily hydropeaking is likely to seriously limit upstream movement in the river close to the dam.

Nottoway River

A population of Roanoke logperch occurs in the Nottoway River and some of its tributaries in the Chowan drainage. The highest densities of logperch are found along the length of river crossing the fall zone between the Piedmont and Coastal Plain physiographic provinces. The most upstream record of logperch in this system is from Fort Pickett; however, only one individual was observed (Angermeier and Rosenberger 2000). Surveys by McIninch and Garman (2002; from Lahey and Angermeier 2006b) between Fort Pickett and the more densely populated areas downstream implied that logperch may be continuously but sparsely distributed along the upstream reaches of the river between Fort Pickett and Dinwiddie county. Logperch may be found in the Nottoway River as far downstream as the border of Sussex County with Southampton County. Only three tributaries of the Nottoway River, Stony, Sappony and Waqua creeks, contain logperch (Lahey and Angermeier 2006b); of the three tributaries, Stony Creek probably has the highest densities of logperch (A. Rosenberger, personal observation). Tributaries in this drainage that flow west to east over the fall zone are more likely to contain high-gradient habitat riffles and runs that may be necessary for logperch to complete their life history. Most of the tributaries of the Nottoway River flow north-south and are small, low gradient, swampy tributaries that do not contain suitable habitat.

Past Distribution

Based on their present, disjunct distribution, Jenkins (1977) and Burkhead (1983) hypothesized that all populations of Roanoke logperch within the Roanoke drainage were historically larger and well connected. They suggested that fragmentation by large reservoirs and destruction of habitat due to massive siltation from agriculture and human development resulted in the current separation of logperch populations in the Roanoke drainage. It is also possible that, prior to European settlement and agricultural expansion in Virginia, the logperch range extended far into the Piedmont and occasionally connected the Nottoway River population with the Roanoke River population. Limited data suggesting low genetic divergence among the Roanoke, Pigg, Smith, and Nottoway river populations of logperch support the notion of a relatively recent separation (George and Mayden 2003); however, more genetic data is needed to establish exact relationships between the four populations (see Research needs). It is also possible that logperch were once present in the Dan, Mayo, and Falling river watersheds.

- e. habitat or ecosystem conditions (e.g. amount, distribution, and suitability of the habitat or ecosystem)?

Differences in habitat availability among rivers containing logperch

For the Roanoke and Nottoway rivers, both meso- and microhabitat characteristics vary in ways that could affect logperch habitat use and limit the similarity of habitat use and life history patterns among these rivers (Rosenberger and Angermeier 2002). Mesohabitat characteristics refer to the characteristics of pools, riffles, and runs in these high- to medium- gradient small rivers and streams (Frissell et al. 1986). Microhabitat characteristics refer to the characteristics of habitat in small, 1-m² areas within mesohabitats. There is presently little information available on mesohabitat characteristics of the Pigg, Smith, or Big and Little Otter Rivers or Goose Creek, but, because these streams are within the Roanoke drainage, mesohabitat availability is probably most similar to the Roanoke River as described below. Microhabitat availability is presently unknown for the Smith River, but visual examination suggests that the upper Smith River above Philpott Reservoir is probably most like the Pigg River as described below, though perhaps less silted, and the lower Smith River is probably most like the upper Roanoke River as described in microhabitat characteristics.

In addition, the following summaries are based on data collected between 1999-2000 (Rosenberger and Angermeier 2002). As human development patterns and management activities change through time, the relative difference in habitat characteristics may also change.

Mesohabitat availability differences between the Roanoke and Nottoway Rivers (summarized from Rosenberger and Angermeier 2002)

Differences between the Roanoke and Nottoway Rivers in mesohabitat characteristics reflect differences between the rivers in physiography, gradient, and anthropogenic disturbance. Pool habitat is dominant, runs uncommon, and riffles are rare in the Nottoway River relative to the Roanoke River. The Nottoway River is a larger and wider system than the upper Roanoke River; therefore, runs and riffles are deeper in the Nottoway River. Within mesohabitats, the most consistent and dramatic differences between the two rivers are in embeddedness, silt cover, and frequency of woody debris. The Nottoway River has less anthropogenic disturbance in its watershed than the Roanoke River, and its riparian zone is relatively intact and almost completely lined with trees through the fall zone. This contributes woody debris and stabilizes banks in the Nottoway River, which, in turn, reduces sediment loads that cover and embed substrate. Exposed root wads, more common in Roanoke River riffles than Nottoway River riffles, are sometimes the result of undercutting that characterizes an unstable streambank. Past studies indicate that logperch avoid areas with heavy silt loads and substrate embeddedness, which are common in the Roanoke River. Choice of swift water with silt-free microhabitats by logperch in this system may compensate for the presence of habitats degraded by sedimentation.

Microhabitat availability differences between the Roanoke, Pigg, and Nottoway Rivers (summarized from Rosenberger and Angermeier 2002)

Differences among the Roanoke, Pigg, and Nottoway rivers reflect their relative size and gradient as well as differences among the systems in human development. The Roanoke and Pigg rivers are experiencing heavy sedimentation from nearby agriculture and construction activities, more so than the Nottoway River system. The Nottoway River is the largest and deepest of the rivers and the Pigg River the smallest and shallowest. The Roanoke River, with the highest gradient, has the largest substrates and highest bottom velocities in riffle microhabitats. The most dramatic differences among rivers are in embeddedness and silt characteristics. For all mesohabitat types, the Nottoway River has the least silted and embedded microhabitats and the Pigg River is most heavily embedded with silt.

2. **Biological Assessment (Or should it be Species Status and Baseline?):** Given the updated information, summarize the biological status of the species. *Provide a synthesis of the new information and information from the reference point documents and last status review to provide an updated status and baseline of the species. Include discussion of status of any experimental populations. To the best of your ability, define the current baseline for the species so you have a benchmark by which to measure the change in status for the next review. [See “Further Guidance on the Role of Experimental Populations”]*

Several ecological characteristics of the Roanoke logperch make it particularly vulnerable to human impacts and alterations of stream environments:

- 1) The distribution of logperch is limited to a relatively small geographic area (Roanoke and Chowan drainages, Virginia).
- 2) The Roanoke logperch is a habitat specialist that depends on loosely embedded gravel for its feeding strategy, for all age classes and during all seasons, and is thus particularly vulnerable to silt deposition, a widespread human impact on Virginia rivers.
- 3) This species exists at low densities, is rarely locally abundant, and is patchily distributed throughout its range.
- 4) It requires multiple habitats over its ontogeny.

Other ecological characteristics of this species may have contributed to its continued persistence despite growing human impact on its environments:

- 1) Although a microhabitat substrate specialists, this species is capable of exploiting a variety of velocities and depths to find suitable feeding substrate and can also forage in woody debris.
- 2) Its relatively large size and drifting larvae could contribute to mobility and ability to recolonize areas where extirpation has occurred.
- 3) Logperch can be found not only in mainstem, medium-sized rivers, but also larger tributaries, which could enable recolonization of logperch following catastrophic extirpation in mainstem areas due to chemical spills (e.g., the Pigg River spill of 1975) or habitat

destruction (e.g., hydropeaking and cold water release from Philpott Dam).

- 4) Populations of this species appear to be able to persist in small geographic areas.

For additional information, see the attached document.

C. Threats: Five-factor Analysis

New Information: Threats:

1. **Threats Assessment (5-Factor Analysis): Given the updated information, provide an analysis of the threats to the species in the context of the 5 listing factors.**

The following section includes a discussion of known and potential threats to Roanoke logperch and the implications and degree of risk associated with each threat for each logperch population (summarized in Table 2). These threats include: 1) Large dams and reservoirs; 2) Siltation and habitat alteration and degradation from watershed urbanization; 3) Widespread sedimentation and siltation from agriculture and forestry; 4) Channelization projects; 5) Past and proposed road building; 6) Toxic chemical spills and fish kills; 7) Loss of riparian vegetation and woody debris; 8) Small barriers to logperch movement; and 9) Water withdrawals.

Table 2. A summary of threats listed in this document and the degree to which each population is at risk based on the particular threat (N = Not a present threat; L = Exists but not a large threat; M = Significantly threatens a subset of the range occupied by logperch; H = Significantly threatens the known range of the population; U = Unknown).

Threat	Population Upper Roanoke River	Middle Roanoke River	Pigg River	Upper Smith River	Lower Smith River	Nottoway River
Large dams	M	M	M	H	H	N
Urbanization	H	U	M	L	M	L
Ag./ Forestry	H	U	M	M	M	L
Channelization	M	U	N	N	U	N
Road Building	H	U	H	L	M	L
Toxic Spills	L	U	H	M	H	L
Riparian Loss	M	U	M	M	H	L
Small Barriers	L	U	M	U	U	U
Water Withdrawals	L	U	U	U	U	L

Large dams and reservoirs

Perhaps the greatest overall loss of logperch habitat and reduction in this species range in the Roanoke drainage occurred when Leesville and Smith

Mountain reservoirs were completed in 1966. Along with habitat degradation from poor land use, the construction of these dams probably extirpated logperch populations within the Piedmont section of the Roanoke River drainage, a hypothesis supported by the presence of logperch in Goose Creek and the Big and Little Otter River. In addition, populations of logperch in the Pigg and Smith Rivers were isolated from Roanoke River populations when these dams were constructed, increasing their vulnerability to extirpation and habitat loss by eliminating any chance of recolonization from upstream habitat.

Philpott Reservoir, which was constructed in 1953, is the greatest current threat to logperch within the Smith River. Upstream of the reservoir, the stretch of occupied river is small, isolated, and therefore vulnerable to other human impacts that affect instream habitat or cause local extirpation. Downstream of the reservoir, hydropeaking and coldwater release make at least 8 river kilometers completely unsuitable for logperch and potentially isolate Town Creek. Logperch in Town Creek could possibly be connected to logperch found 8-20km downstream of the dam; however, the connection between these two locales has not been investigated and cannot be assumed. Daily flooding from hydropeaking and unsuitably cold temperatures characterize the Smith River at its confluence with Town Creek. Any additional dam development upstream of Philpott, including the proposed but presently stalled Charity Reservoir (Jenkins and Burkhead 1993), could extirpate the logperch population upstream of Philpott Reservoir.

The Nottoway River is among the few rivers in Virginia located in the Piedmont and Coastal Plain physiographic provinces that do not have major barriers to movement in the form of lowhead dams or reservoirs along the relatively high gradient transition (fall zone) between the two provinces. Increasing development in the coastal areas around Newport News, Virginia could lead to increased interest in the relatively clean water found in this river system. However, impoundment of this river anywhere along the fall zone would seriously threaten its logperch population. Smaller dams upstream of the fall zone around the town of Blackstone are unlikely threats to the present range logperch and may actually protect downstream areas from sedimentation or spills that originate near the town; however, they could cause isolation and restrict upstream range expansion.

Habitat alteration and degradation from watershed urbanization

Wheeler et al. (2005) reviewed the effect of urbanization on stream habitat. The following section is directly based on their review; contents of this review are compared against what is understood about the ecology of Roanoke logperch to summarize this growing threat to Roanoke logperch.

Urbanization fundamentally alters the delivery of water to streams and alters stream flow regimes. As a watershed urbanizes, peak flow volume from precipitation events increases, thereby increasing the frequency of bankfull

flows. Increasingly severe flows could affect larval drift and year-class strength of Roanoke logperch, and flooding during the winter months could destabilize silt-free velocity shelters and increase overwinter mortality for this species.

The increased frequency of bankfull flows following urbanization causes a stream to increase its channel capacity by eroding its banks, downcutting its channel, or both (Wheeler et al. 2005). This increases the amount of fine sediment entering the stream. In addition, in a watershed with rapid development, construction projects are common, which have potential to dramatically increase the level of sediment entering streams. Although single projects are likely to have only temporary effects, continuous construction from multiple projects can sustain these effects. Excessive stream sedimentation reduces habitat heterogeneity, causes egg and larval mortality, abrades organisms, reduces visibility for sight predators, reduces macroinvertebrate productivity, and limits the rock-flipping feeding behavior of Roanoke logperch. Long stretches of river thickly covered with silt may act as barriers to movement and could fragment populations of logperch.

Impervious surfaces increase peak flow but decrease base flow. Base flows result from subsurface flow and groundwater that steadily contributes to streams between precipitation events. Because impervious surfaces prevent precipitation from infiltrating below the surface, urban streams are characterized by low base flows. Low flows combined with the effects of channel enlargement, results in urban streams that feature oversized stream channels with little water between runoff events. This reduces the availability of deep, swift water preferred by logperch for feeding, reproduction, and winter habitat.

Urbanization typically results in loss of streamside (riparian) vegetation as areas near streams are cleared. The degree of riparian disturbance can vary with type of urban land use; however, riparian vegetation is critical for stream function. The contribution of riparian vegetation to water quality (by filtering out chemicals, sediment, and stabilizing stream bank and shading water from temperature-increasing sunlight) and habitat (in the form of woody debris from falling riparian trees) indicates that urban projects that remove riparian trees along rivers inhabited by logperch could be detrimental for this species.

Rivers and streams receive the majority of urban runoff. Large quantities of stormwater drain from urban streets, parking lots, and lawns, containing a variety of pollutants (e.g., petroleum, heavy metals) and nutrients into the river. Pollutants can be stored in stream water and sediments and accumulate in stream biota; however, the extent to which this affects logperch populations is unknown (See Research Needs).

One of the worst threats of urbanization is that its effects are extremely difficult to reverse once they occur. Very low levels of urbanization (8%-10% of the watershed) result in highly altered stream habitat, and successful restoration of

affected communities can be costly or near impossible, resulting in a shift into a new, less desirable state that is difficult to reverse. In contrast, although agriculture can have similar effects, streams may support relatively healthy fish communities until agricultural land cover exceeds 80% of the watershed, and the effects of agriculture are easier to reverse through restoration activities (Wheeler et al. 2002).

Because projects that affect endangered species are typically evaluated on a one-by-one basis, and urbanization ultimately results from the 'tyranny of small decisions' (Odum, 1982), the cumulative effects of urbanization could be ignored for Roanoke logperch. Further, the cumulative effects of individual projects are overlooked by the Clean Water Act section 404 permitting process.

The human population in and around the Roanoke area, including Blacksburg and Salem, Virginia is continuing to expand. This is accompanied by the usual symptoms of watershed urbanization, including expanding impervious surfaces, increased urban sprawl, and loss of open areas and farmland. This could negatively affect all populations within the Roanoke River drainage, including ones in the Pigg and Smith rivers.

The area around the Nottoway River inhabited by Roanoke logperch is primarily used for agricultural or forestry purposes. The only areas that could be considered at all urban occur near the headwaters of the Nottoway River in and around the town of Blackstone. Urbanization is not one of the primary threats to logperch in this system at this time, but new development may become an issue as human populations in the area expand.

Widespread siltation and habitat degradation from agricultural activities

The most widespread threat to Roanoke logperch is non-point source pollution in the form of fine sediment from both urban and agricultural activities. Particularly in the Roanoke drainage, crop and livestock farming contributes deposits of fine sediment and silt into the upper Roanoke, Pigg, and Smith rivers. In upstream reaches, cattle often have unrestricted access to the stream channel; as a result, failing and highly eroded streambanks are common. However, widespread restoration activities and improved farming practices in these areas have a strong potential for dramatically reducing silt loads and improving logperch habitat. Restoration activities in agricultural areas are much more likely to be successful than in urban areas (See previous section on urbanization effects).

Historically, the Nottoway River was impacted by excessive siltation generated by poor agriculture and farming practices. Recent surveys indicate that both agriculture and forestry practices have improved along the Nottoway River, and siltation is less of an issue in this system than it is in the Roanoke drainage (Rosenberger and Angermeier 2002). Large hurricanes and subsequent high flow events that passed through the system may have assisted in flushing out

any silt that would be a legacy of past impacts. Further, most of the streambank along the fall zone of the Nottoway River is forested (A. Rosenberger, personal observation). However, the highly erodible soils in the area, together with the potential for expanding agriculture and forestry, indicate that this threat could easily resurface. If siltation increases in the Nottoway River drainage, pools, which presently appear to be suitable for Roanoke logperch during the summer growing season, would be the mesohabitats most affected by deposition, and could potentially become unsuitable. This could force logperch into swift-water areas, but, because swift-water habitat is relatively rare within the low-gradient Nottoway River and becomes more rare as the summer progresses (Rosenberger and Angermeier 2002), this would considerably reduce the amount of available habitat for Age 1+ logperch and potentially eliminate suitable habitat for small and large YOY.

Channelization projects

As stated in the original Roanoke logperch recovery plan (USFWS 1992), the morphology of rivers in the Roanoke drainage, particularly the upper Roanoke River, have been altered in many locations due to filling activities to support industrial parks and residential areas and through small-scale channelization at local farms.

However, the largest project in extent in intensity that could affect Roanoke logperch is being conducted in Roanoke County along the entire length of the Roanoke River within the City of Roanoke limits by the U.S. Army Corps of Engineers. This project was proposed in 1989 but did not begin until fall of 2005. The purpose of this project is to protect property loss from flooding, particularly damage from small (~2 ft) floods. The objective of this project is to enhance the speed and volume of water conveyed downstream during floods by removing impediments to stream flow (instream wood), channel straightening, streambank stabilization (training walls and riprap), and physical widening of the floodplain at channel bends (K. Smith, personal communication).

The Roanoke River Flood Reduction Project will involve earth-moving activities that will likely temporarily increased sediment input into the rivers, and may therefore negatively effecting Roanoke logperch. Acute effects of the construction also include direct mortality from heavy equipment crossing the streambank.

Permanent alterations to stream habitat that the channelization project would cause could include: 1) loss of ability to move out fine sediment; 2) loss of peripheral, side-channel habitat in which small YOY logperch occur; and 3) loss of woody debris. It is possible that channel destabilization from the project will add more fine sediment than the channel can move. In that case, there may be a need to dredge the channel later, compounding the effects of the channelization project. All of these factors together could cause a decrease in

logperch populations in and around the City of Roanoke during and after construction. This decrease may be delayed because much of the effect of the channelization project will be on YOY habitat (low-flow areas and side channels).

Past and proposed road and highway building

Urbanization and continued economic growth around the City of Roanoke, Salem, and town of Blacksburg has also resulted in an increase in new highway, highway improvement, and paved road projects. In particular, the Virginia Department of Transportation is proposing to build a highway (I-73) that will potentially impact all populations of Roanoke logperch in the Roanoke drainage. Paved road construction impacts on Roanoke logperch can be summarized in three dimensions: 1) road construction; 2) road presence; and 3) urbanization (Angermeier et al. 2004; Wheeler et al. 2005). Much of the discussion below is a summary based on more thorough literature reviews and conceptual arguments contained in Angermeier et al. (2004) and Wheeler et al. (2005), who reviewed the effects of road building, presence, and subsequent urbanization on stream biota and a report by Wheeler et al. (2002) that assessed via literature review the potential impact of the proposed I-73 on stream habitat and Roanoke logperch.

Road construction

During road construction, acute and heavy siltation can occur locally in nearby streams and rivers. Although mitigation techniques are available and required near stream habitat, they are not always properly maintained. After particularly heavy rainfall, preventative devices such as silt fencing can fail and result in localized extirpation of logperch through excessive sedimentation. Even with the presence of functioning silt fences, fine sediment loading can still increase in nearby streams (see previous sections for effects of siltation and fine sediment on Roanoke logperch). In addition, streams around bridges and highways are often channelized and straightened, which results in greater fine-sediment deposition and eliminates peripheral habitats important for YOY logperch (see previous section on channelization threats).

Road presence

Unlike the acute, local and physical nature of the impacts of road construction, the impact of an adjacent road on streams is primarily chronic, regional and chemical. Once construction ceases, most effects of road construction are corrected naturally through time; however, the effects of the presence of a road perpetuate themselves through time. Streams near roads accumulate chemical pollutants from automobile traffic which are released to streams by runoff. These pollutants accumulate in stream sediment and biota and are transported downstream resulting in both chronic and regional effects. Roads collect metals, oil and grease from automobile traffic and release these to streams during rainfall events. A study in the Roanoke River watershed found higher levels of lead and zinc in aquatic macroinvertebrates when traffic at

upstream road crossings was heavy (Van Hassel et al. 1980). From the same study, Ney and Van Hassel (1983) reported fantail darters and blacknose dace had higher concentrations of lead, zinc, nickel and cadmium. The effects of heavy metals and pollutants on Roanoke logperch are unknown, but could be considered an additional threat (see Research Needs). Toxic chemical spills and deicing salt are more acute effects of road presence. Deicing salt is also a common chemical pollutant of streams, and toxic chemical spills occur frequently along bridges and highways and often enter stream ecosystems with negative consequences on biota (See section on threats from spills).

Urbanization

Roads are often constructed to encourage urban development and result in an increase in urbanization, whose impacts are difficult to quantify but potentially severe (see previous section on threats associated with urbanization).

Potential Impacts of the Proposed I-73 Corridor (summarized from Powell et al. 2002)

The proposed construction of Interstate 73 (I-73) addresses concerns set forth by Congress to improve movement of goods between states, encourage economic development, and address local safety needs. I-73 is considered a “high priority” by Congress and will connect Sault St. Marie, Michigan and Myrtle Beach, South Carolina, including a 75 mile-long corridor through southwestern Virginia. A recent Natural Resources Technical Memorandum (NRTM), study prepared by the Virginia Department of Transportation (VDOT 2000) identified several potential routes for I-73 construction through the upper Roanoke, Pigg, and Smith River watersheds.

The impacts of the proposed I-73 corridor through the City of Roanoke on Roanoke logperch should be minimal. The current corridor follows the existing roads I-81 and I-58, following the present route of 220 through the community of Clearbrook, east of where 220 crosses the Blue Ridge Parkway. After passing through Clearbrook, the proposed path cuts north east again to presently unpaved ground in Franklin County. Because this corridor follows existing roads through the City of Roanoke, it will require minimal construction, thus lessening the potential for impacts. Another advantage of this route through the City of Roanoke is that it traverses areas that are already highly urbanized and developed, thus the danger from the impacts of future watershed urbanization is also minimized. Additionally, the proposed corridor is very near the downstream limit of Roanoke logperch in the upper Roanoke River, thus most Roanoke logperch in this region are located safely upstream of this corridor.

The population of Roanoke logperch in the Pigg River appears to be the most fragile and sensitive to the proposed interstate. The proposed corridor crosses the Pigg River 3km east of Rocky Mount, and thus the majority of Roanoke logperch in the Pigg River are downstream of the crossing, where they could be directly impacted by any chemical spills on highway or nearby road crossings or carelessness during construction. Watershed urbanization is also a substantial threat to Roanoke logperch in the Pigg River. Given the

proximity of the area to the City of Roanoke and the reduced travel time provided by a new interstate, this area would likely develop quickly. Considering that only a small percentage of the Pigg River watershed is urban land, the biota of the Pigg River would be drastically harmed by the onset of urbanization. In contrast, the Smith River populations of logperch are well upstream of the proposed interstate and thus would likely be unimpacted.

Toxic Spills and Fish Kills

The effects of toxic spills on stream biota are typically acute and localized; however, in populations already weakened by restricted distributions and loss of habitat, they can be catastrophic. Toxic spills can originate accidentally or purposefully, from stationary storage facilities in agricultural or urban centers or, more frequently, from trucks transporting the material. It was difficult to obtain concrete information on the frequency and extent of recent chemical spills on Roanoke logperch populations in Virginia (see Research Needs); however, limited information indicates that spills are common and should be considered a persistent threat (Burkhead 1983; USFWS 1992; Wheeler et al. 2002).

Wheeler et al. (2002) describe the extent to which hazardous material transport could affect populations of Roanoke logperch. They state that hazardous materials are often moved by truck and, in 1982, composed almost a quarter of all domestic freight shipments. Accidental releases are frequent (e.g., 1738 occurrences from 1976-1984 in Virginia alone). US EPA reports an average of 10,000 accidental releases of 646,000 gallons of hazardous materials annually on U.S. highways between 1990 and 1994 (EPA 1996). The most severe of these incidents known to occur in the logperch range occurred in the Pigg River in 1975, when a discharge of copper sulfate from an accident in Rocky Mount (upstream of most of the logperch habitat in the Pigg River) caused a kill of an estimated 28,704 fish (many species, including logperch) over 36km of river (James 1979). The Pigg River is still the most likely population to be extirpated from a toxic spill. The reason for this is because the Pigg River population occurs over a very short length of river, has only one tributary locale known to contain logperch that could serve as a source for recolonization, and is located downstream of a major thoroughfare in Rocky Mount and the crossing of the proposed I-73. However, any Roanoke logperch downstream of any potential storage facilities for toxic chemicals or manure or major road crossings (e.g., Stony Creek tributary of the Nottoway River, Town Creek tributary of the Smith River) should be considered at risk of this potential threat. Even if these locales are not completely extirpated by a chemical spill, resulting genetic bottlenecks could reduce the adaptive potential of logperch populations, cause inbreeding depression, and decrease resilience to demographic and environmental stochasticity.

Removal of Woody debris

Within the Fall Zone of the Nottoway River, woody debris, including large tree falls and snags, are a common sight (Rosenberger and Angermeier 2002). Roanoke logperch in this river are commonly observed in and around woody debris in low flow areas (Rosenberger and Angermeier 2002), which may serve as cover from predators and a source of food (Angermeier 1985). Wood removal practices and the deforestation of streambanks in streams and rivers of the Roanoke River basin has greatly reduced the availability of wood in these systems due to loss of riparian vegetation and intentional debris removal in urban areas (e.g., Roanoke River Flood Reduction project). It may be not only the silt cover but also the lack of woody debris in Roanoke River pools that reduce pool suitability for Roanoke logperch (see previous section on Habitat Use).

Small dams and movement barriers

Small, lowhead dams and relict, unused dams are scattered throughout the range of Roanoke logperch and may form a barrier to logperch movement. One such dam can be found on the Pigg River, just downstream of the town of Rocky Mount and in the Smith River close to Martinsville. The extent to which these dams flood potential logperch habitat, prevent the connectivity of logperch populations, or restrict the distribution of logperch is unknown and deserves further investigation (see Research Needs). It is also possible that small dams and movement barriers are trapping and retaining toxic materials and sediment that would otherwise be harming logperch.

Water Withdrawals

The extent to which water withdrawals affect logperch populations in the Roanoke River drainage is unknown and probably minimal. One water withdrawal project occurs in the Nottoway River; a titanium mining operation (Iluka Resources) in Dinwiddie and Sussex Counties withdraws water from the Nottoway River for their processing facility in Sussex County. However, withdrawal is minimal and strictly regulated (Saunders, personal communication); as long as withdrawal does not contribute to the drying of swift-water areas in the Nottoway River during the spring reproductive period, and other projects do not demand additional withdrawal, it is probably only a minor threat to the logperch in this system in drought years.

- D. Recovery criteria: Does the updated information on the species indicate that any or all of the recovery criteria for downlisting, delisting or uplisting have been met?**

No.

- 1) Criteria: All four populations are stable or expanding and protected from foreseeable threats:
 - a. Roanoke River population – stable or expanding. However, threats are increasing in scope and severity.

- b. Pigg River population – expanding. Threats also increasing in scope and severity.
 - c. Smith River population – stable or declining. Threats remain the same as when listing occurred.
 - d. Otter River - unknown
 - e. Goose Creek – unknown
 - f. Nottoway River – stable or expanding. Threats declining, but population not protected from foreseeable threats.
- 2) Abundance and/or range size is increased for the Roanoke River population and at least two other populations.
- a. Roanoke River population – decline in range for Mason Creek, increasing in range elsewhere. Whether this reflects an actual increase in range or increased sampling effort is unknown. No evidence that abundances have declined or increased.
 - b. Pigg River population – increase in range and abundance, probably reflecting slow recovery after the 1975 chemical spill and extensive fish kill at this location.
 - c. Smith River population – range remains the same and population remains perilously small.
 - d. Otter River – unknown population; represents an increase in range in the Roanoke River drainage.
 - e. Goose Creek – unknown population; represents an increase in range in the Roanoke River drainage.
 - f. Nottoway River – Increasing in range and possibly abundance with declining threats. Also unknown if this reflects an actual increase in range or an increase in sampling effort.

IV. Results: *After review of sections I, II, III,*

- A.** **Given your responses to sections I, II, and III, does the 5-year review indicate that a change in classification is warranted?** No. Criteria for downlisting have not yet been completely met, though the species is showing signs of improvement despite growing threats on logperch populations.
- B. Priority Numbers: If the results of this review indicate a change in status is warranted, or a significant change in status/knowledge of the species, determine appropriate priority numbers.**
1. **Recovery priority Number:** *Based on this review, indicate the appropriate Recovery Priority Number for the species. The 5-year review should substantiate this change, so provide only a brief rationale. Notify the Washington Office of the change during the annual Recovery Data Call. [See “55 FR24296” for NOAA and “48 FR 43098” for FWS]*

2. **If applicable, indicate the Listing and Reclassification Priority Number (FWS only).** *The priority number will assist in prioritizing staffing, funding, and development of proposed rules to reclassify or delist a species. [See “The Endangered and Threatened Species Listing and Recovery Priority Guidance (48 FR43098)”]*

Reclassification (from Threatened to Endangered) Priority Number:_____

Reclassification (from Endangered to Threatened) Priority Number:_____

Delisting (Removal from list regardless of current classification) Priority Number:_____

Recommendations for Future Actions:

Section V. RESEARCH NEEDS

Although research in the last decade has dramatically increased our understanding of Roanoke logperch ecology, there are many avenues of research that would inform management for this species and add to our knowledge of their ecology and life history. Below are suggested avenues of research based on the author’s expert opinion and evaluation of the literature, including suggestions from Roberts and Angermeier (2004). These are in no particular order of priority because the importance of the information from research depends on the management question.

14. Development of a spatially-explicit decision support model for managers that evaluates the relative cost/benefit of management or restoration activities in terms of cost and potential risks or benefits to logperch populations. Multiple threats to logperch populations that are more or less problematic depending on the location of the threat and multiple potential management activities (including inaction) that would provide variable benefit depending on the location and cost of the activity make successful conservation and restoration of this species a complex and daunting task. A decision support model that explicitly takes into account these factors can be used to identify areas where conservation activities could be performed to maximize benefits at the least cost and identify areas where conflicts may occur or restoration activities would have minimal effect. In addition, this document recommends a watershed-level approach to conservation (see section on Management Recommendations) and a comprehensive, spatially-explicit decision support model would support that approach.

15. With an eye towards establishing a rigorous monitoring program, evaluation of sampling efficiency of Roanoke logperch for various sampling approaches (e.g., snorkeling and electrofishing), including habitat correlates of sampling efficiency (e.g., streamflow, temperature, and stream size) and differences between young-of-year and juveniles/ adults. Previous studies have shown that logperch can be marked with minimum risk of mortality with elastomer tags (Rosenberger and Angermeier 2002); therefore, establishing a 'known' population of logperch to resample using different techniques, though difficult, is possible.
16. A complete census of the use and availability of habitat for young-of-year logperch for all populations.
17. A better understanding of why logperch range extends to some areas, but not others. For example, is it due to habitat constraints, the legacy of past human impacts, or other reasons? Is this controlled at the reach or watershed scale? Could logperch persist in places where they aren't now but probably were historically?
18. Understanding the potential for logperch to recolonize extirpated areas and recover from disturbance begins with an understanding of their mobility. This understanding could arise through rigorously-designed mark-recapture studies together with an analysis of gene flow at the population level.
19. Genetic studies of known logperch populations can not only give an indication of gene flow and mobility, but also the relative density and strength of these populations for future monitoring purposes. Nuclear markers with a high degree of variability would be most useful for these purposes (e.g. microsatellites, MHC complexes). From these data, there is potential to obtain information on: 1) population structure of the species; 2) historical and current population size; 3) degree to which populations are connected by dispersal; and 4) the amount of movement of physical space involved in completing the logperch life-cycle, though other means would be needed to confirm these results.
20. A better understanding of watershed-scale correlates of Roanoke logperch presence and year-class strength (e.g., summer stream flow), with an eye towards understanding what stochastic and deterministic variables regulate logperch population dynamics. These can be related to potentially important local features of habitat, such as availability of young-of-year rearing and feeding habitat through the growing season or the flushing of silt and sediment. Studies on the Roanoke River indicate that stochastic factors, such as springtime stream flow, could be very important determinates of year-to-year variability in logperch population densities. This hypothesis can be contrasted against the hypothesis that rearing and/or feeding habitat are limiting logperch densities. If habitat is not what

is limiting for these populations, then habitat restoration will have limited effect on increasing logperch population densities and/or range and achieving recovery objectives.

21. For all logperch populations, a better understanding of logperch mortality rates and causes at different life stages (e.g., predation from non-native predators, starvation, high flows) and what habitat choices may mitigate those sources of mortality.
22. Population-specific descriptions of the reproductive cycle and reproductive habitat use of Roanoke logperch. Both thermal and flow conditions, which differ among rivers, may be important cues for the onset of logperch reproductive behavior.
23. A better evaluation of how existing and proposed road projects, industrial centers, or storage facilities will increase the risk of localized or large-scale extirpation of logperch populations through toxic chemical spills. This evaluation should include an assessment of potential source populations of Roanoke logperch should a spill occur and an understanding of major routes for transporting potentially toxic material. This analysis will allow managers to direct their attention to the most high priority areas for prevention of spills.
24. An inventory of movement barriers in the form of poorly maintained culverts or unused power or lowhead dams throughout the range of logperch that could be removed to improve the connectivity of populations. This study should also include an assessment if lowhead dams are protecting logperch by holding back damaging sediment or toxins trapped in sediment and should be ranked by isolating effect, economic value, and potential for removal.
25. A better understanding of the frequency and extent of effects of chemical pollutants from urban runoff on logperch populations. Urbanization is dramatically increasing over the entire range of Roanoke logperch. This is a growing threat that is not well understood.
26. A better understanding of how riparian condition affects sediment loading in rivers and how much buffer is required to reduce the amount of sediment entering streams containing Roanoke logperch.

Section VI. MANAGEMENT AND RECOVERY RECOMMENDATIONS

Management approach

Protection of a species based on a single life stage, such as the adult stage, or protection that ignores potential for spatial variation in demographic processes over multiple scales is naturally incomplete. Each size class of Roanoke

logperch selects particular habitat configurations, and the species uses a wide range of habitats over its ontogeny. Successful conservation of this species will therefore involve the preservation of the ecological processes that maintain the connected habitat mosaics required over logperch life history. Specific attention should be paid to the creation of and access to mesohabitat types such as backwaters and clean pools as well as relatively silt-free microhabitats with low to intermediate water velocities.

Our understanding of Roanoke logperch microhabitat use indicates that loosely embedded sediment free of heavy silt cover is critical growing habitat for this endangered species. The peculiar feeding habits of logperch necessitate the availability of loosely embedded gravel that can be flipped by a small fish to reveal aquatic insects. Management programs that enhance the natural streamflow of occupied rivers should include protection of the streambank from agricultural and construction practices that contribute silt loads. Scouring flow during natural flood events should also enhance habitat through removal of small sediments, particularly in backwaters that are rarely exposed to scouring water velocities. Historic and ongoing floodplain development, especially in the Roanoke River drainage, can threaten logperch habitat, particularly backwaters and shorelines that appear to be important for YOY logperch. However, it seems evident that a natural flow regime will not be sufficient to provide needed habitats if sediment loading remains or becomes elevated in systems occupied by logperch.

In addition to protecting logperch from threats that affect populations incrementally and slowly, it will be important to protect Roanoke logperch from catastrophic loss due to water projects and chemical spills. A spatial understanding of how these threats are distributed over the landscape and may differentially affect fish populations will be necessary to effectively manage these threats (see Research Needs).

All of the information contained in this document suggests that a piecemeal approach to conservation will be ineffective if recovery of this species is to be achieved. Evidence that Roanoke logperch requires a low-silt, complex habitat mosaic over multiple spatial scales indicates that reach-specific management approaches will not ensure the recovery and persistence of this species. In addition, the extent to which listed threats affect logperch differs from location to location and from population to population. Based on this, I recommend a range-wide watershed-level approach to logperch conservation and recovery that addresses all threats in a spatially explicit manner. For the Roanoke drainage, management could put particular emphasis on sediment loading and preserving natural flow regimes that provide ephemeral, seasonal, and persistent types of habitat required over logperch ontogeny. It could also concentrate on increasing the population connectivity.

For the Nottoway River, emphasis should be placed on monitoring, preservation, and prevention of catastrophic events, as this unique system

shows signs of increasing health and a strong logperch population. Emphasis could be placed on protecting potential limiting habitats, such as swift water reproductive habitat during the spring spawning season by enacting more stringent water withdrawal regulations.

Proposed Recovery Objectives

Proposed Recovery Objective 1: Maintain and increase the health and vigor of present populations through a watershed-level conservation approach that addresses sediment loading and preserves ecological processes that provide ephemeral, seasonal, and persistent types of habitat required over logperch ontogeny. Avoiding a piecemeal conservation approach will reduce threats from urban sprawl and industrial development. Although potentially degrading agricultural activity has the potential to adversely affect logperch throughout its range and may be responsible for historical declines, three areas are particularly degraded by agricultural activities and may be good areas for stream restoration projects and projects to improve agricultural practices: 1) the North Fork of the Roanoke River; 2) the Pigg River upstream of the town of Rocky Mount; and 3) the Smith River upstream of Philpott Reservoir. Additional restoration work in the Town Creek population of Roanoke logperch could also increase the value of this locale for logperch. Areas that help maintain existing habitat for logperch should be aggressively preserved and maintained.

Proposed Recovery Objective 2: Expand the present range of Roanoke logperch by identifying unoccupied areas with suitable habitat within its previous range and reintroducing logperch into those locations with consideration for genetic and local adaptation consequences as well as the capacity of the receiving habitat for maintaining a persistent population of Roanoke logperch. If genetic considerations outweigh the benefits of the range increases, this objective may need to be abandoned. In addition, a place should not be identified as 'unoccupied' unless extensively sampled using validated techniques so that managers can be at least 95% confident that no existing logperch can be found in those sites or in nearby sites that could seed natural recolonization.

Proposed Recovery Objective 3: Increase connectivity of Roanoke logperch populations by identifying major and minor artificial movement barriers and eliminating them when feasible. This should occur only with consideration for potential for opening pathways of dispersal for nonnative species like rock bass, release of toxic or fine sediments, and an understanding of whether these dams are protecting downstream logperch from excessive sedimentation upstream.

Proposed Recovery Objective 4: Prevent and reduce the risk of catastrophic extirpation from large spills through maintenance and improvement of present highway and road-crossings and enforcement and educational displays at

likely dumping locations. Insure population maintenance and recolonization potential by increasing population connectedness, maintaining and monitoring peripheral locales that could be source populations in the event of a catastrophic spill (e.g., tributary populations), and considering potential loss of populations or locales through spills for evaluation of any proposed bridge or highway construction within the range of the Roanoke logperch.

Proposed recovery benchmarks

Benchmarks have limited meaning and use unless there is a sound basis for the present condition of logperch populations and intensive and validated monitoring. Assuming that sound data are available, this document proposes the following new benchmarks to be established in order for logperch to be downlisted to 'Threatened' status under the Endangered Species Act:

- 8) A stable or increasing trend in logperch population densities in indicator sites located at both central and peripheral locales for all 6 populations of logperch over a 20-year period (3 logperch generations).
- 9) A stable or increasing trend in the range extent of all six populations over a 20-year period.
- 10) A stable or increasing trend in overall population strength (for definition see below under 'Proposed Recovery Practices') for all six populations over a 20-year period.
- 11) An increasing trend in the overall strength of Roanoke logperch populations in at least 3 of the defined populations (recommended benchmark = 25%; for definition on strength, see below under 'Proposed Recovery Practices')
- 12) A stable or increasing trend in the continuity of all six populations. This will involve the removal of movement barriers, improved dam release practices to improve the continuity of logperch habitat, and restoration of stream reaches that fragment populations by creating long reaches of unsuitable logperch habitat.
- 13) A stable or increasing trend in the length of occupied stream channels with high quality logperch habitat, e.g. habitat that is silt-free and suitable for all life stages of Roanoke logperch.
- 14) A stable or declining trend in known threats to Roanoke logperch for all 6 populations.

Proposed recovery practices:

- 1) Establish a defensible metric for logperch population and locale strength that could be used for regulatory purposes. The research proposed above may inform or alter this metric. Based on present available research, I propose the following information be included in such a metric:
 - a. Age 1+ density along several indicators along the length of river occupied. YOY densities can be patchy in time and space and are

- less reliably captured; however, densities should be monitored to obtain information on the spatial and temporal variability of this life stage.
- b. Length of river occupied by logperch (i.e., distributional extent or range)
 - c. Number of potential movement barriers
 - d. % of occupied stream length with high quality habitat for each life stage of logperch
 - e. Number of locales along the length of stream that can act as sources of recolonization should stream lengths be extirpated due to catastrophic spills
 - f. Length of river upstream and downstream of known threats
 - g. Weight of threat based on degree of risk to logperch populations
- 8) Establish an intensive and defensible monitoring protocol to monitor logperch population strength based on this metric using validated methods and multiple remote and site-based approaches.
 - 9) Determine the amount of sediment loading coming from different threats and reduce sediment loading by at least 50% through restoration activity.
 - 10) In lieu of designating critical habitat, create a GIS layer of all threats in each watershed (e.g., toxins, urban development, agricultural inputs). Designate Roanoke logperch protected habitat, and, within these protected areas, use restrictive zoning and wide riparian buffers to protect logperch habitat.
 - 11) Within Roanoke logperch protected habitat, establish minimum riparian buffers necessary to stabilize stream banks and reduce silt loads. A minimum of 20 meters should be set until research better establishes what the width of buffer should be in different areas containing logperch.
 - 12) Establish a maximum impervious surface below the threshold required to maintain a healthy watershed (10%; Wheeler et al. 2002). New construction must undergo strict regulation and take place with mitigation measures to reduce the impact of increased impervious surfaces and other effects of urbanization.
 - 13) Any road, highway, bridge, or ramp construction or maintenance should include an assessment of the risk to populations through spills. Retention ponds at likely spill locations should be constructed to reduce risk.

Monitoring recommendations

Monitoring of logperch densities should occur on two facets: 1) density of logperch populations in *both* population strongholds (e.g., upper Roanoke River) and in peripheral areas (edges of their ranges, e.g., North Fork Roanoke River, close to Leesville Reservoir in the Pigg River). Information on other species suggests that population declines are often first detected away from the 'core areas' (Isaak and Thurow 2006), and, instead of declining uniformly, species will remain in similar densities in population strongholds and decline only in the peripheral areas with suboptimal habitats. If monitoring for logperch

is concentrated only in its strongholds, it may not work for detecting population declines. Additional monitoring should occur to confirm and monitor the limits of logperch ranges, which appear to be increasing with increasing sampling effort (Lahey and Angermeier 2006b).

Care should be taken in both cases to use validated sampling approaches (see Research Needs section). Monitors should keep in mind that validation involves more than simply using consistent protocols from year to year. Creating comparable data sets involves collecting data that has clear meaning in terms of both precision and accuracy relative to the unknown true population parameters of interest. Using a common protocol is an important step in standardization but cannot guarantee common, comparable, or defensible results. Assessments of measurement error can require additional resources and are often logistically very time-consuming and require great effort. However, validation of sampling methods is a short-term investment compared to the long term benefits of increased confidence in data quality and the ability to compare data using a variety of methods and approaches with known precision and accuracy. Such investments are well worthwhile in terms of the value of information and the implications for sound management decisions.

A clear understanding of sampling efficiency can be related both to the detectability of a species and the reliability of abundance estimators. For example, if one has a reasonable estimate of sampling efficiency, then one can estimate how much effort it will take to detect the presence of Roanoke logperch in a particular site, and how much weight should be placed on absence data. False absences are likely to be common when sampling logperch because of the likely low sampling efficiency of this species (Lahey and Angermeier 2006a). Absences should be treated with the proper amount of skepticism until sampling efficiencies and what affects sampling efficiency is better understood.