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Monitoring of Endangered Roanoke Logperch (*Percina rex*) in Smith River Upstream from the Philpott Reservoir on U.S. Army Corps of Engineers Property near Martinsville, Virginia

Open-File Report 2012–1221

U.S. Department of the Interior
U.S. Geological Survey

Cover photograph. Smith River near White Falls, Virginia (photograph by James Roberts, Department of Fish and Wildlife Conservation).

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KEN SALAZAR, Secretary

U.S. Geological Survey
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Conversion Factors and Abbreviations

SI to Inch/Pound

Multiply	By	To obtain
	Length	
millimeter (mm)	0.3937	foot (ft)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m^2)	0.0002471	acre
hectare (ha)	2.471	acre

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C=(°F–32)/1.8

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88)

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83)

Abbreviations and Acronyms

USACE	U.S. Army Corps of Engineers
ESA	U.S. Endangered Species Act
VT	Virginia Tech
VCFWRU	Virginia Cooperative Fish and Wildlife Research Unit
IACUC	Institutional Animal Care and Use Committee
TL	Total length
≤	Less than or equal to
>	Greater than
SE	Standard error
SD	Standard deviation
<	Less than
NTU	Nephelometric turbidity units
TC	Temperature-corrected
Raw	Not temperature-corrected
ATV	All-terrain vehicle

Monitoring of Endangered Roanoke Logperch (*Percina rex*) in Smith River Upstream from the Philpott Reservoir on U.S. Army Corps of Engineers Property near Martinsville, Virginia

By James H. Roberts[1] and Paul L. Angermeier[2]

Introduction

The purpose of this study was to continue annual monitoring of Roanoke logperch (*Percina rex*), an endangered fish, in the Smith River immediately upstream from Philpott Reservoir. This river reach is owned by the U.S. Army Corps of Engineers (USACE), which must ensure that appropriate actions are undertaken to aid in recovery of logperch. Monitoring of fish abundance and habitat conditions provides a means for assessing the species' status and its responses to USACE management actions.

The Roanoke logperch is a large darter (Percidae: Etheostomatinae) endemic to the Roanoke, Dan, and Nottoway River basins of Virginia and North Carolina, where it occupies third- to sixth-order streams containing relatively silt-free substrate (Jenkins and Burkhead, 1994). Because of its rarity, small range, and vulnerability to siltation, the Roanoke logperch was listed in 1989 as endangered under the U.S. Endangered Species Act (ESA) (U.S. Federal Register 54:34468-34472).

Within the Dan basin, Roanoke logperch have long been known to occupy the Smith River and one of its largest tributaries, Town Creek (Jenkins and Burkhead, 1994). Logperch also recently were discovered in other tributaries of the Dan River, including North Carolina segments of the Mayo River, Cascade Creek, Big Beaver Island Creek, Wolf Island Creek (William Hester, U.S. Fish and Wildlife Service, personal commun., 2012). Within the Smith River, Roanoke logperch are present both upstream and downstream from Philpott Reservoir, a hydroelectric and water storage project owned and operated by the USACE. Although logperch have not been observed in the reservoir itself, the species is relatively abundant in a free-flowing, ≈ 2.5-km-long segment of Smith River upstream from the reservoir on USACE property (Lahey and Angermeier, 2006). This segment is bounded on the downstream end by the lentic conditions of the reservoir and on the upstream end by White Falls, a natural waterfall that presumably allows fish passage during all but the lowest streamflows (Roberts and Angermeier, 2009; fig. 1).

The ESA stipulates that USACE must ensure that its actions do not jeopardize Roanoke logperch and ensure that appropriate actions are taken to aid in the recovery of Roanoke logperch. USACE recognized that additional information was needed to assess compliance with these stipulations, including data on baseline population levels, habitat availability, and potential threats to the species on USACE property. USACE therefore contracted with Virginia Tech (VT) and the U.S. Geological Survey via the Virginia Cooperative Fisheries and Wildlife Research Unit (VCFWRU) to continue ecological monitoring that was initiated in a pilot study in 2005 (Lahey and Angermeier, 2006). The VCFWRU is jointly sponsored by the U.S. Geological Survey, Virginia Tech, Virginia Department of Game and Inland Fisheries, and Wildlife Management Institute.

This final report summarizes results of biological monitoring performed by VT and the VCFWRU in 2011, and compares these data to data collected during 2006–2010 (Roberts and Angermeier, 2011). Where appropriate, a comparison was made to data on Roanoke logperch collected previously in the study reach (Lahey and Angermeier, 2006) and in the upper Roanoke River (Roberts and Angermeier, 2011). This work was performed under the auspices of VT's Institutional Animal Care and Use Committee (IACUC) protocol 11-035-FIW. Specifically, the following objectives were addressed:

- Estimate population density of Roanoke logperch on USACE property;
- Measure and map by suitability class the distribution of habitat suitable for Roanoke logperch in the project area;

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Figure 1. The Smith River at White Falls at the time of sampling, October 9, 2011.

- Assess water quality relative to Roanoke logperch habitat in the project area;
- Use the data on logperch abundance, habitat suitability, and water quality to test the general validity of correlates of logperch abundance from other locations;
- Identify opportunities and threats related to protecting and enhancing Roanoke logperch habitat; and
- Provide suggestions on the necessity and scale of future studies and monitoring related to logperch in and near USACE waters.

Objective 1: Estimate population density of Roanoke logperch on USACE property

Data were collected between October 9 and 10, 2011 at each of the five permanent monitoring sites that were established by Roberts and Angermeier (2007; fig. 2). Each site comprised a riffle-run complex that was deemed to contain at least some microhabitat configurations that were suitable for Roanoke logperch. At each site, an 80-m-long permanent transect parallel to the stream channel previously was established by driving steel rods into the streambank at 12-m intervals on one side of the river (Roberts and Angermeier, 2007). Precise locations of the downstream- and upstream-most rods at each site were determined for this report by using a handheld geographic positioning system device. During fish and habitat sampling (see below) temporary transects were established at 12-m intervals along the permanent transect (that is, at each steel rod) that extended across the stream channel, perpendicular to the permanent transect.

The preferred method for estimating population density of Roanoke logperch in fall (September–October) consists of electrofishing into a stationary seine (Roberts and Angermeier, 2011). In fall 2010, logperch were captured by electrofishing fixed-area net-sets along temporary transects (see previous paragraph) at each site. The first net-set was positioned on the downstream-most transect of a site, 1 m from one of the streambanks. The second quadrat was positioned along the same transect, adjacent to and 1 m from the first. As many non-overlapping quadrats as would fit on each transect were sampled, given the length of the transect (that is, the stream width). Occasionally areas of the stream were skipped that, based on best judgment, exhibited velocity too high to position the net or too low to sweep fishes into the net. The above procedures were replicated at each upstream transect. During electrofishing, a 2-m-tall, 4-m-wide, 5-mm-mesh bag seine was positioned 4 m downstream from

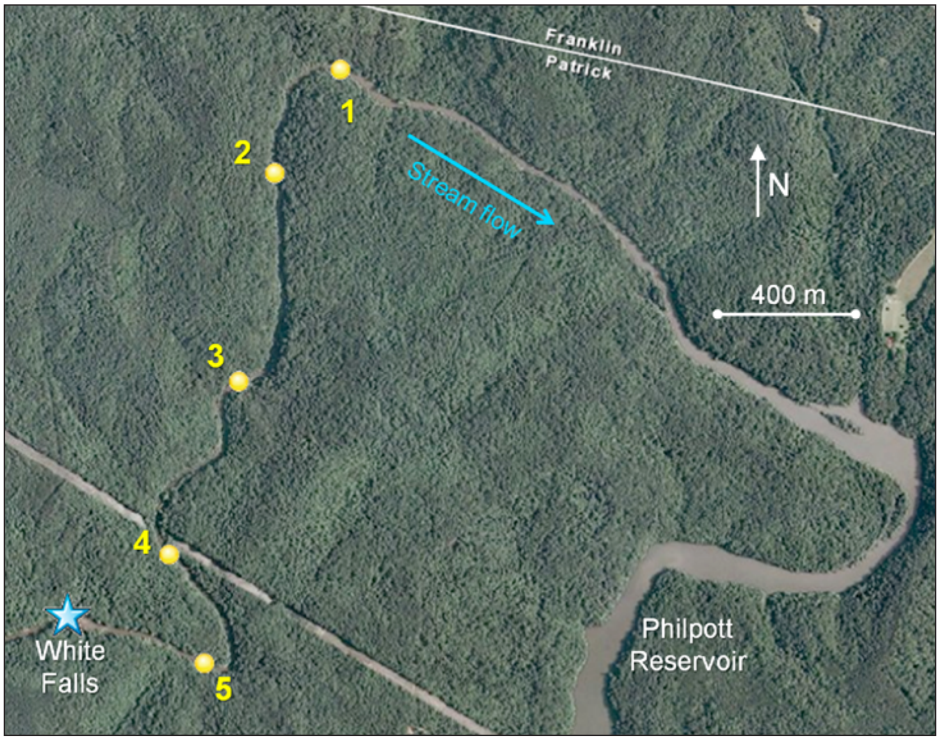

Figure 2. Location of the five sample sites (yellow circles) on the Smith River upstream from Philpott Reservoir.

the transect. Then, beginning 4 m upstream from the transect, a backpack electrofisher made three rapid downstream passes into the seine. Thus, a 32-m^2 area (4 m wide x 8 m long) was sampled by each net-set. Following electrofishing of a net-set, the seine was quickly pulled up and hauled to the streambank, where captured fishes were processed. Captured logperch were pooled across all quadrats in a site to determine the abundance of logperch in the site. Logperch abundance subsequently was converted to population density (number ha^{-1}) based on the area (number of net-sets) sampled at a site.

Captured logperch were sorted into age classes based on total length (TL; Roberts and Angermeier, 2011): for fall-captured logperch, fish ≤ 95 mm TL were Age-0 and fish > 95 mm TL were Age-1+. After Age-0, fish age cannot be reliably determined based on size. Because they are standardized by effort, population density estimates can be compared across sites and time periods.

A total of nine Roanoke logperch were captured in fall 2011, of which six were Age-1+ and three were Age-0 (table 1). Population density ranged from 0.0 to 104.2 total individuals ha^{-1} at individual sites and averaged 50.9 total individuals ha^{-1} over all sites. This density was within the range observed in previous years.

Annual variation in population density was shown to be high at almost all sites for both Age-0 and Age-1+ logperch (fig. 3). The only exception was site 5 (the upstream-most site), which exhibited relatively stable Age-1+ density. Spatial peaks and troughs of Age-1+ logperch density did not seem to coincide with peaks and troughs of Age-0 logperch density. Age-0 density tended to be high at sites 1 and 5 and low at sites 2, 3, and 4, whereas Age-1+ density tended to be high at site 4 and low at site 1. This lack of correlation is not surprising, given that adult and juvenile logperch exhibit preferences for different habitat configurations (Rosenberger and Angermeier, 2003). Furthermore, previous genetic findings suggested that logperch dispersal within the USACE-owned reach was extensive, such that the spatial distribution of Age-1+ and Age-0 fish during fall does not necessarily reflect the distribution of fish during spawning (Roberts and others, 2008; Roberts and Angermeier, 2009). Spatial patterns of Age-1+ and Age-0 density are similarly asynchronous in the upper Roanoke River (Roberts and Angermeier, 2011).

Objective 2: Measure and map by suitability class the distribution of habitat suitable for Roanoke logperch in the project area

Lack of suitable habitat may be the primary factor limiting the distribution and abundance of Roanoke logperch, both rangewide and in the Smith River (Jenkins and Burkhead, 1994; Rosenberger, 2007). This, combined with the difficulty of estimating logperch abundance given its rarity, suggests that the availability of high-quality habitat may provide both a useful index of the viability of the logperch population in the Smith River and a means of interpreting spatiotemporal variation in logperch abundance. A GIS-based

Table 1. Observed abundances and estimated densities of Roanoke logperch during fall 2011 at five permanent sites in the USACE-owned segment of the Smith River.

[Abundance and densities were estimated based on numbers of individuals per hectare. Logperch age-classes were distinguished based on fish total length. SE represents one standard error]

Site	Site length (meters)	Number of net-sets	Logperch abundance			Logperch density (ha^{-1})		
			Age-0	Age-1+	All	Age-0	Age-1+	All
1	80	12	0	0	0	0.0	0.0	0.0
2	80	12	0	0	0	0.0	0.0	0.0
3	80	11	0	2	2	0.0	56.8	56.8
4	80	10	1	2	3	31.3	62.5	93.8
5	80	12	2	2	4	52.1	52.1	104.2
Total	400	57	3	6	9			
Mean	80	11.4	0.6	1.2	1.8	16.7	34.3	50.9
SE	0	0.4	0.4	0.5	0.8	10.7	14.1	22.2

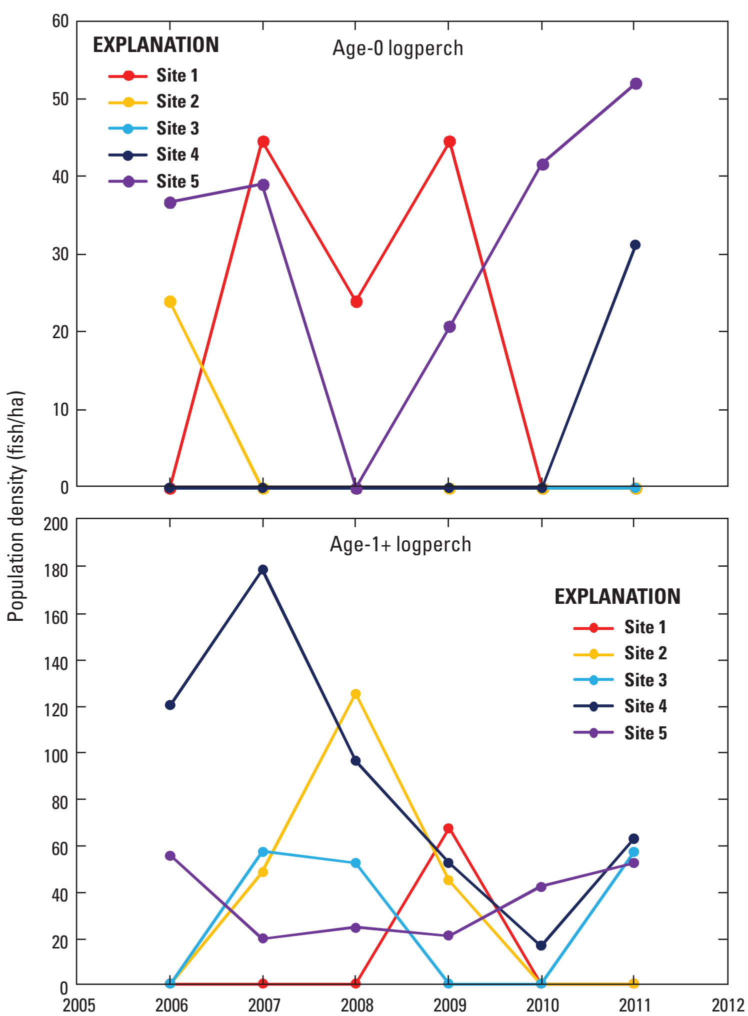

Figure 3. Variation in the population density of Age-0 (top panel) and Age-1+ (bottom panel) Roanoke logperch among five sites across six years.

approach to habitat assessment and mapping has been developed and successfully applied in the upper Roanoke River (Ensign and Angermeier, 1994; Ensign and others, 1998), and application of the methodology to the Smith River was described by Roberts and Angermeier (2007). These methods were adoped to assess the availability of habitat suitable for Roanoke logperch at each Smith River site during fall 2011.

Maps showing the distribution of suitable and unsuitable habitats at each site during fall 2011 are shown in figures 4 through 8. On average, 24 percent of the habitat cells that were sampled at sites featured “high-quality” (good to excellent) habitat for Roanoke logperch in fall 2011, whereas 30 percent of the cells featured “low-quality” (poor to unsuitable) habitat (table 2).

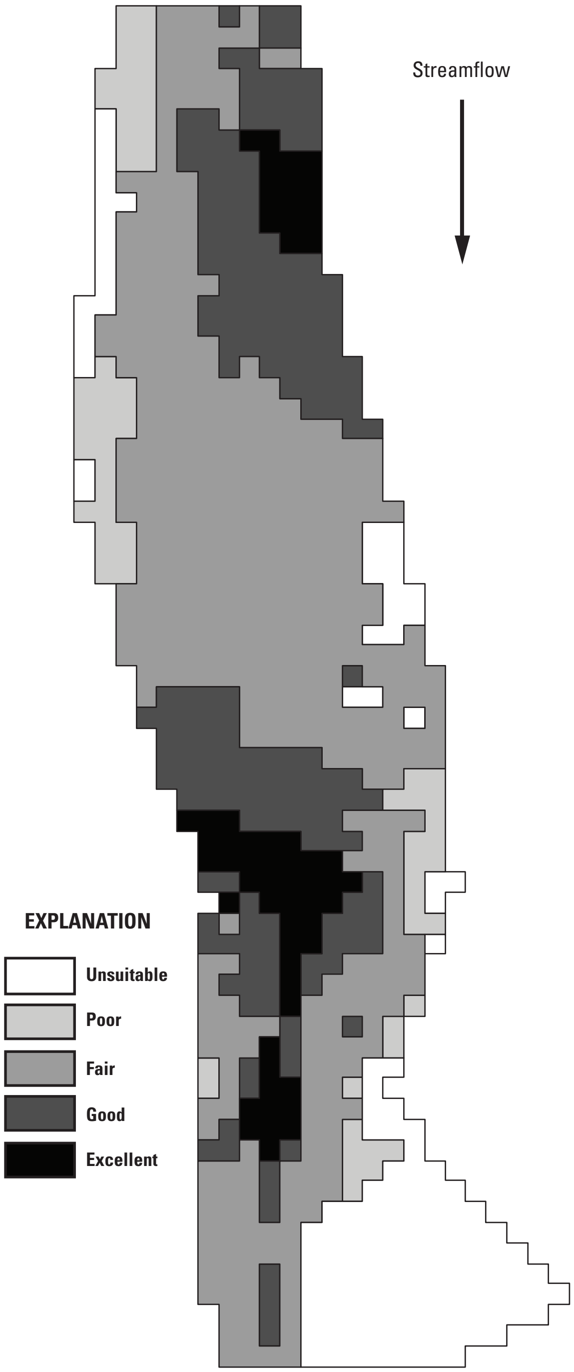

Figure 4. Distribution and quality of microhabitat cells (1.5-m^2 pixels) at site 1 during fall 2011. Microhabitat cells were classified according to suitability for Age-1+ Roanoke logperch using transect-based habitat data and a habitat suitability index that was developed by Ensign and Angermeier (1994) and Ensign and others (1998) based on observations of logperch in the Roanoke River.

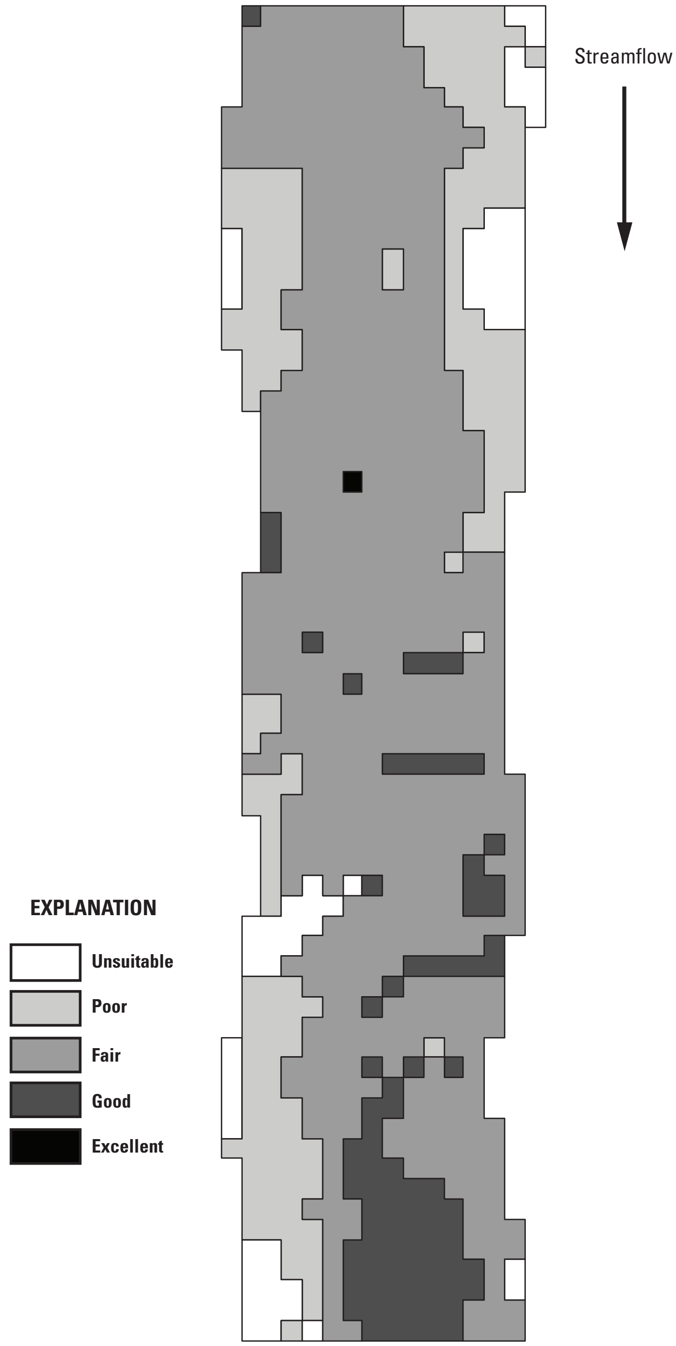

Figure 5. Distribution and quality of microhabitat cells (1.5-m^2 pixels) at site 2 during fall 2011. Microhabitat cells were classified according to suitability for Age-1+ Roanoke logperch using transect-based habitat data and a habitat suitability index that was developed by Ensign and Angermeier (1994) and Ensign and others (1998) based on observations of logperch in the Roanoke River.

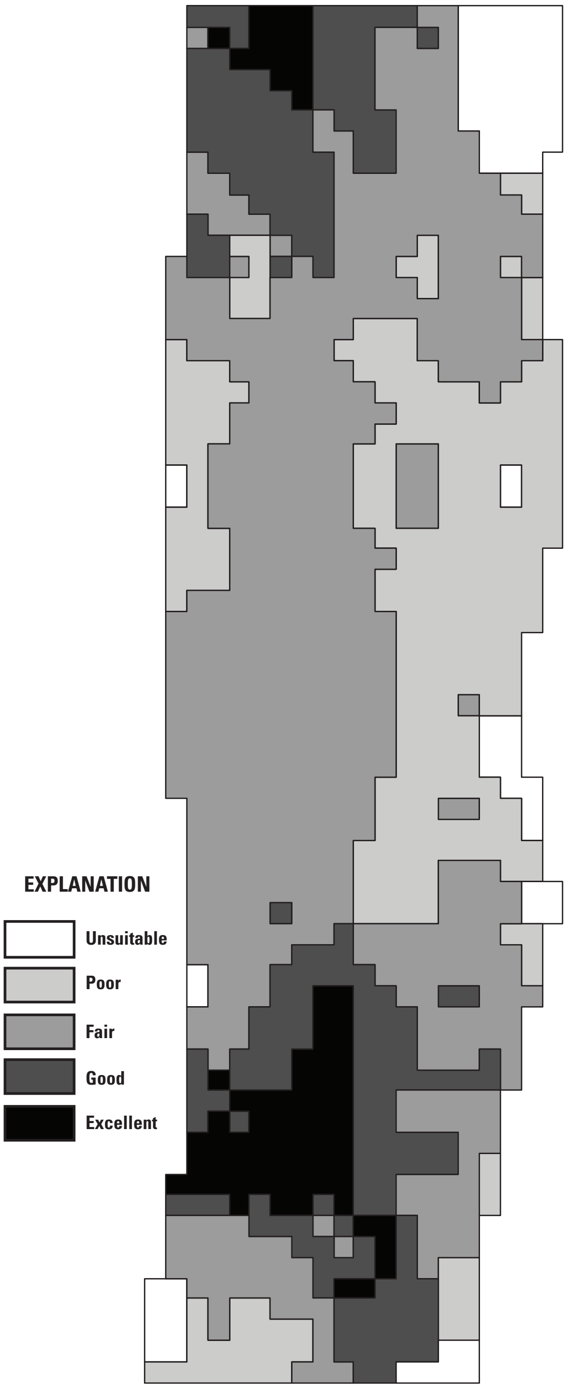

Figure 6. Distribution and quality of microhabitat cells (1.5-m^2 pixels) at site 3 during fall 2011. Microhabitat cells were classified according to suitability for Age-1+ Roanoke logperch using transect-based habitat data and a habitat suitability index that was developed by Ensign and Angermeier (1994) and Ensign and others (1998) based on observations of logperch in the Roanoke River.

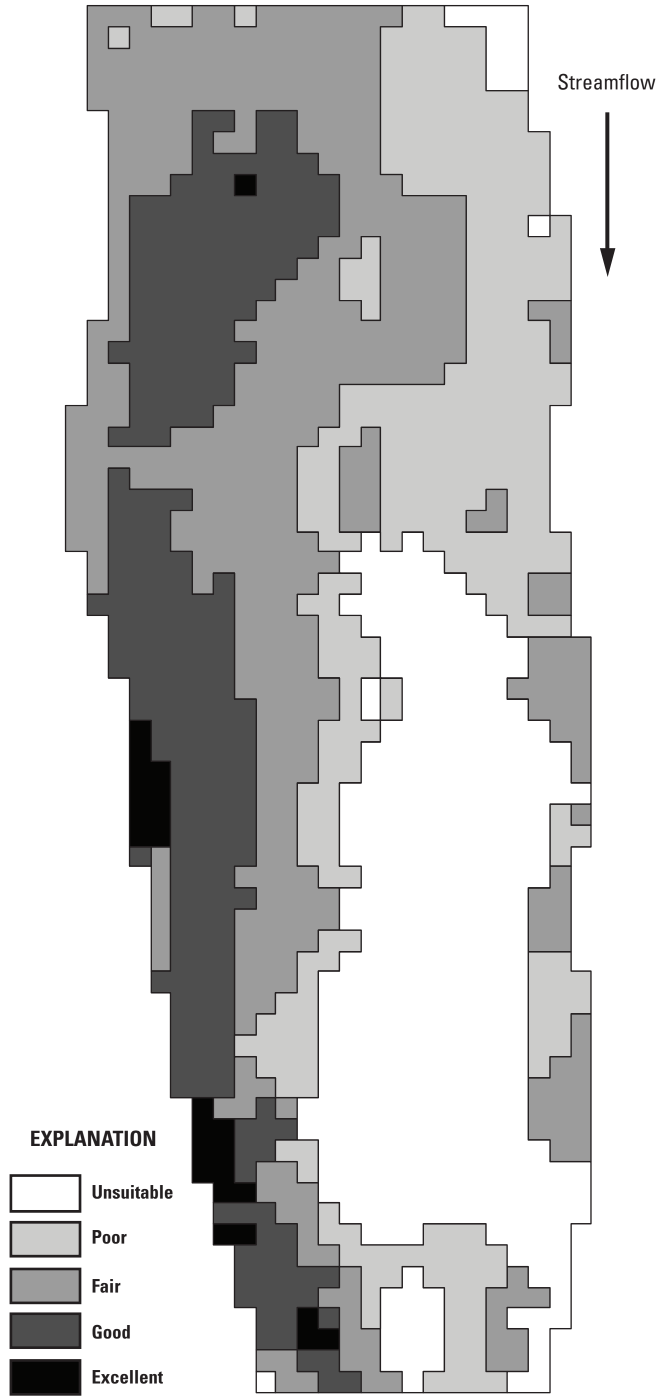

Figure 7. Distribution and quality of microhabitat cells (1.5-m^2 pixels) at site 4 during fall 2011. Microhabitat cells were classified according to suitability for Age-1+ Roanoke logperch using transect-based habitat data and a habitat suitability index that was developed by Ensign and Angermeier (1994) and Ensign and others (1998) based on observations of logperch in the Roanoke River.

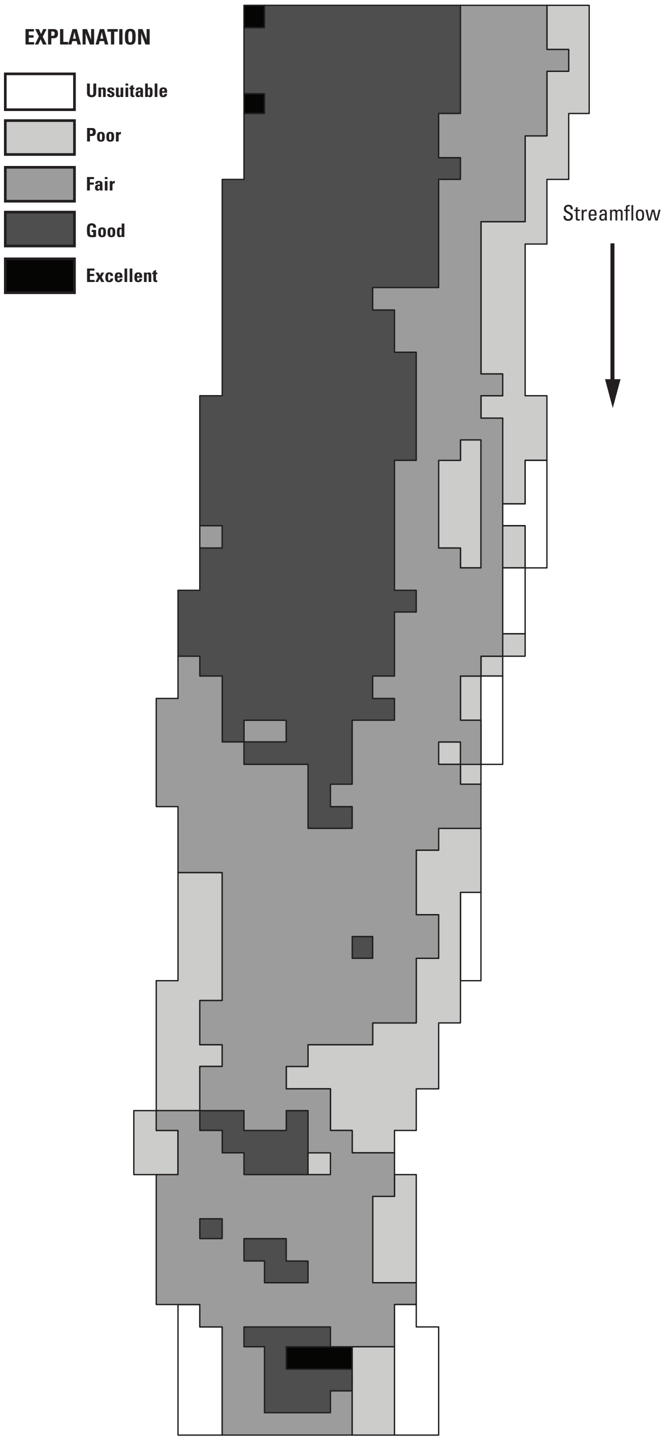

Figure 8. Distribution and quality of microhabitat cells (1.5-m² pixels) at site 5 during fall 2011. Microhabitat cells were classified according to suitability for Age-1+ Roanoke logperch using transect-based habitat data and a habitat suitability index that was developed by Ensign and Angermeier (1994) and Ensign and others (1998) based on observations of logperch in the Roanoke River.

Annual variation in habitat suitability may be related to annual variation in the streamflow of the Smith River, as estimated by the U.S. Geological Survey streamgaging station near Woolwine (table 3). The estimated percentage of high-quality habitat is strongly positively correlated with the streamflow during habitat sampling, as well as with the mean and standard deviation of streamflow during the spring (April 1 through June 30) leading up to the sample (table 4). Elevated spring streamflows may scour away previously deposited silt, thereby increasing habitat suitability. Elevated streamflows during sampling may increase the depth and velocity of microhabitat cells, which increases habitat suitability scores.

Patterns of temporal variation in habitat conditions are more distinctive than patterns of spatial variation. The availability of high-quality Age-1+ habitat at sites varies consistently among years (fig. 9). That is, if availability of high-quality habitat increases (or decreases) between years at one site, it tends to increase (or decrease) at all sites. Some spatial patterns are also evident. First, site 5 tended to exhibit greater availability of high-quality habitat than sites 3 or 4. Second, site 3 exhibited less annual variability than other sites, possibly because of its deep morphology and prevalent unsuitable bedrock substrate, which make habitat suitability calculations at the site less sensitive to hydrologic variation. Furthermore, spatial variation in habitat quality did not clearly relate to spatial variation in Age-1+ or Age-0 logperch density. This lack of spatial correlation between habitat and logperch density also has been observed in the upper Roanoke River (Roberts and Angermeier, 2011), and suggests that logperch migrate among sites over their lifetimes, and therefore, that recruitment and carrying capacity are determined more at the reach scale than at the scale of an individual site or riffle.

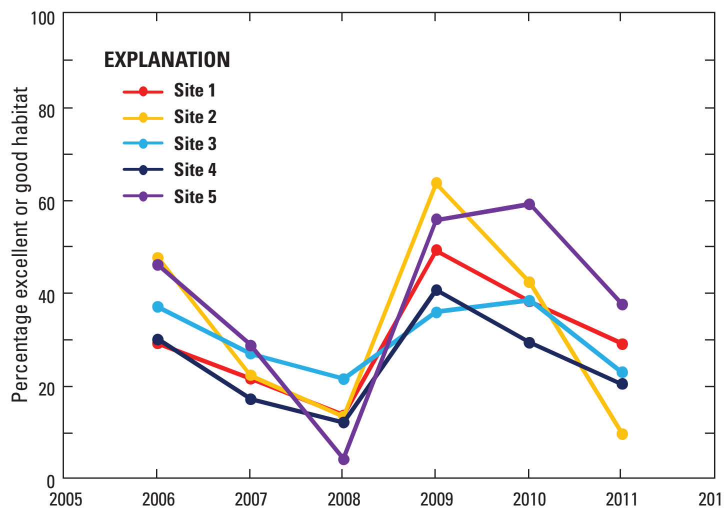

Figure 9. Variation among five sites across 6 years in the percentage of sampled microhabitat cells featuring "excellent" or "good" Age-1+ Roanoke logperch habitat. Microhabitat cells were classified using a habitat suitability index that was developed by Ensign and Angermeier (1994) and Ensign and others (1998) based on observations of logperch in the Roanoke River.

Table 2. Distribution of Age-1+ Roanoke logperch habitat suitability classes during fall 2011 at five permanent sites in the USACE-owned segment of the Smith River.

[Column entries are the percentages of the total site area estimated to be in the designated suitability class. SE represents one standard error. The habitat suitability index used to evaluate habitats was developed by Ensign and Angermeier (1994) and Ensign and others (1998) based on observations of logperch in the Roanoke River]

Site	Suitability classification (percentage of site)					Total area (square meters)
	Unsuitable	Poor	Fair	Good	Excellent	
1	16.2	7.9	46.9	22.0	7.1	1905.7
2	7.0	20.2	63.1	9.6	0.1	2031.7
3	6.3	23.6	47.1	16.5	6.5	2553.7
4	25.3	22.2	32.1	18.6	1.8	3064.5
5	4.2	16.0	42.3	37.0	0.5	2110.5
Mean	11.8	18.0	46.3	20.7	3.2	2333.2
SE	4.0	2.8	5.0	4.5	1.5	212.9

Table 3. Annual variation in the mean and standard deviation of daily discharge of the Smith River during spring and during fall fish sampling, as well as the corresponding estimates of overall Roanoke logperch density and mean percentage of high-quality microhabitats at sample sites.

[Discharge data were obtained between April 1–June 30 from the U.S. Geological Survey streamgage near Woolwine, Virginia. ft^3, cubic feet; ha, hectare; SD, standard deviation]

Year	Spring streamflow ($ft^3\ s^{-1}$)		Sampling streamflow ($ft^3\ s^{-1}$)	Overall Age-0 logperch density	Overall Age-1+ logperch density	Mean percentage excellent-good habitat
	Mean	SD	Mean	(fish ha^{-1})	(fish ha^{-1})	
2006	30.7	36.8	28	13.4	35.7	38.0
2007	48.4	17.8	14	18.4	59.7	23.4
2008	34.3	23.2	10	5.1	56.4	13.0
2009	73.0	50.1	22	13.4	35.7	49.0
2010	46.9	17.9	15	11.6	8.3	41.4
2011	53.3	23.2	12	16.4	32.9	24.0

Table 4. Interannual correlations between variables shown in table 3.

[Variables include the mean (SpringMean) and standard deviation (SpringSD) of streamflow of the Smith River during spring (April 1–June 30) and streamflow during fish sampling (Sampling), as well as estimates of overall Age-0 and Age-1+ Roanoke logperch density and the mean percentage of high-quality (good or excellent) habitat at sample sites. Discharge data were obtained from the U.S. Geological Survey stream gauge near Woolwine, Virginia. None of these correlation coefficients are significantly larger than expected by chance ($P < 0.05$), but values > 0.5 are highlighted in bold]

	SpringMean	SpringSD	Sampling	Age-0	Age-1+
SpringSD	0.46				
Sampling	0.01	**0.72**			
Age-0	0.38	–0.02	0.20		
Age-1+	–0.18	–0.05	–0.23	–0.01	
Habitat	**0.51**	**0.64**	**0.72**	0.23	**–0.66**

Objective 3: Assess water quality relative to Roanoke logperch habitat in the project area

Water-quality conditions were measured at each site on October 9, 2011 (table 5). All previously measured water-quality variables were measured, with the exception of turbidity, which could not be measured because the turbidimeter malfunctioned. As a consequence, turbidity at all sites was visually estimated and determined to be < 1 NTU during sampling. Overall, water quality exhibited only minor between-site variability, which was expected given the proximity of the sites to each other. Based on published accounts (Jenkins and Burkhead, 1994) and data from the Roanoke River, water quality in the Smith River during fall 2011 was well within ranges acceptable for use by Roanoke logperch (Roberts and Angermeier, 2011).

Objective 4: Use the data on logperch abundance, habitat suitability, and water quality to test the general validity of correlates of logperch abundance from other locations

Using regression-tree analyses, Roberts and Angermeier (2011) found that temporal variation of logperch abundance in the upper Roanoke River partly could be explained by temporal variation in the magnitude of streamflow during the winter and spring preceding the sample. Logperch were estimated to be more abundant in years during which streamflow was moderate and had relatively low variability. Presumably, high streamflows cause displacement and/or mortality of logperch, but moderate streamflows are necessary to scour silt from feeding and spawning habitats.

Table 5. Water-quality variables as measured at all sites on October 9, 2011.

[Water conductivity was recorded both with (TC) and without (Raw) accounting for water temperature. The mean and standard error (SE) of water quality variables across sites are given. The turbidimeter malfunctioned on the day of sampling, so turbidity measurements are not given, however, the visual estimate of turbidity was less than 1 NTU at all sites. mg/L^{-1}, milligrams per liter; µS, microsiemens; °C, degrees Celsius]

Site	pH	Turbidity (NTU)	Dissolved oxygen (mg/L^{-1})	Raw conductivity (µS)	TC conductivity (µS)	Water temperature (°C)
1	7.8	–	9.9	48.8	62.9	13.2
2	8.0	–	9.6	51.5	63.2	15.3
3	8.1	–	10.1	52.1	63.6	15.6
4	7.9	–	9.7	51.3	63.6	15.0
5	7.9	–	9.5	51.3	63.7	14.8
Mean	7.9	–	9.8	51.0	63.4	14.8
SE	0.05	–	0.10	0.57	0.15	0.42

Multiple regression analysis is not yet possible in the Smith River, because the record contains only 6 years of data. However, based on bivariate correlations, logperch density does not appear to be strongly related to streamflow (tables 3 and 4). Estimated Age-1+ logperch density is weakly negatively correlated, and Age-0 density weakly positively correlated, with the mean of streamflow during spring (April 1 through June 30) and with the mean of streamflow during fish sampling. Density of both age classes is weakly negatively correlated with the standard deviation of spring streamflow. In contrast, Age-1+ density is more strongly negatively correlated with the percentage of high-quality habitat. Because habitat quality itself is collinear with streamflow, the latter relationship was considered spurious. This same, presumably spurious, negative correlation between fish density and habitat quality has been observed in the Roanoke River. In the 2009 Smith River report (Roberts and Angermeier, 2010), bivariate correlations suggested stronger relationships between hydrologic variability and logperch density. This change in results given additional observations indicates the danger of placing too much emphasis on such findings and underscores the need for longer-term monitoring to understand mechanisms influencing logperch population dynamics.

Objective 5: Identify opportunities and threats related to protecting and enhancing Roanoke logperch habitat

Foreseeable threats to Roanoke logperch and their habitats in the Philpott reach of Smith River appear to be minor based on our observations and appear to have remained unchanged since our last survey (Roberts and Angermeier, 2011). Human activity seems uncommon within the USACE-owned reach; we obseved no dwellings or roads there. The operation of all-terrain vehicles (ATVs) in and near the stream may represent the greatest human impact to the Smith River within the study reach, given that it creates tracks of exposed soil that sloughs into the river during heavy rains. We did not assess the prevalence and distribution of ATV activities and their impacts "on the ground," or how these impacts vary over time. Such an assessment may be best performed using time series of satellite imagery or aerial photography, analyzed in a GIS. We did observe relatively few entry points of ATVs into the river channel. Limiting access of ATVs to the floodplain of the Smith River may protect the banks and channel of the river from erosion due to ATV use. The greatest threats to the USACE-owned reach may be from increasing urbanization and pollution further upstream in the Smith River watershed.

Objective 6: Provide suggestions on the necessity and scale of future studies and monitoring related to logperch in and near USACE waters

If the USACE objectives for managing waters near Philpott Reservoir include development of baseline information on the distribution and abundance of Roanoke logperch, as well as spatiotemporal variation in these parameters, a prudent strategy would be to continue monitoring logperch population density, availability of suitable logperch habitat, and water quality at the five sites described herein. Annual samples, collected in fall (September–October), would provide a sound basis for analyzing interannual variation in logperch abundance, and potentially lead to greater understanding of the factors (for example, the recruitment of juveniles, availability of habitat, and hydrologic variability) that regulate logperch abundance in the upper Smith River. Such knowledge is particularly valuable given the availability of a comparable dataset from the upper Roanoke River; analyses of similarities and differences between rivers should provide valuable insight into factors regulating logperch abundance overall. For example, preliminary comparisons between rivers suggest that hydrologic variation may affect the two logperch populations in different ways. Collection of additional samples over a wider range of hydrologic scenarios may allow the estimation of maximum and/or minimum streamflow thresholds that are critical for logperch population dynamics. Such biologically linked models could be used to increase the effectiveness of conservation efforts for Roanoke logperch, both upstream and downstream of the Philpott Reservoir (Orth et al., 2004).

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