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Post-flood recovery and distributions of fishes in the New River Gorge National River, West Virginia

David I. Wellman Jr.
West Virginia University

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David I. Wellman, Jr.

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Stuart A. Welsh, Ph.D., Chair
Douglas B. Chambers, B.S.
Kyle J. Hartman, Ph.D.
J. Todd Petty, Ph.D.
Jesse Purvis, Ph.D.

Division of Forestry

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ABSTRACT

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David I. Wellman, Jr.

The following thesis contains three chapters. The first chapter introduces and reviews literature on disturbances in streams (e.g. flood and drought), recovery of impacted lotic systems, introduced species and New River fish distributions. Chapter 2 provides a synthesis of native and nonnative fish distribution data of the New River Gorge National River (NRGNR). Sixty-two species were documented within or near the NRGNR. Thirty-one (50%) are considered nonnative. The third chapter consists of a study that estimated seasonal abundances of native and nonnative fishes in small tributaries of NRGNR during a 20 month time period following July 2001 floods, and examined among-season stability in abundances of native and nonnative fishes across the 20-month time series. Twenty-nine species were observed (15 native and 14 nonnative) and patterns of recovery were influenced primarily by four natives (stoneroller, blacknose, dace, creek chub, and green sunfish) and four nonnatives (telescope shiner, whitetail shiner, smallmouth bass, and rainbow darter). Abundances of most species did not increase monotonically over the 20-month study period, but fluctuated among seasons. Abundances of nonnative fishes were generally less stable than those of natives across the 20-month time series. Seasonal variation in abundances among species was attributed to historic ecological factors, summer drought, immigration and emigration associated with seasonal habitat shifts, and juvenile recruitment.

DEDICATION

To my grandparents, Ira and Irene Wellman and my wonderful wife and son, Stacy and Garrett.

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Chapter 1: Introduction and Literature Review

INTRODUCTION

This thesis includes two manuscripts on studies of fishes within the New River Gorge, West Virginia. The first study (Chapter 2) synthesizes historic and current distribution data of native and nonnative fishes within the New River Gorge. In the second study (Chapter 3), the species order and timing of post-flood recolonization of fishes in the New River Gorge were examined. Introductions and literature reviews are provided below.

Fish distributions

An understanding of current and historic fish distributions within the NRGNR is a critical management need for the National Park Service. Previous fish surveys focused largely on the New River mainstem and larger tributaries (see citations below), and indicate a high percentage of nonnative species. I collected fish distribution data from 26 tributaries within park boundaries. A synthesis of fish distribution data from recent and previous surveys (Chapter 3) provides managers of the NRGNR with information on distributions and range expansions of native and nonnative species.

Flood, drought, and fish recolonization

During June and July, flash floods occur commonly on small Appalachian streams after intense late afternoon thunderstorms (Messinger and Hughes 2000). On 8 July 2001 training thunderstorm cells in a mesoscale convective complex caused severe flash floods in southern West Virginia including portions of the New River Gorge National River (NRGNR). Rain accumulation ranged from 76-140 mm within a 3 – 6 hour period with maximum rainfall rates of 38-65 mm per hour (NOAA 2003). A second flash flood event on July 26 in the NRGNR resulted from 51-102 mm of rain accumulation within a six-hour period (NOAA 2003). Flood waters and debris flows restructured stream channels, scoured streambeds, removed riparian vegetation, created large alluvial fans, and reduced or extirpated fish populations in several tributaries within NRGNR park boundaries

In contrast, West Virginia received below-average rainfall during summer 2002 and ranked 5th in August drought conditions among all states (NOAA 2003). As a result, many tributary reaches within the NRGNR dewatered completely or reduced to isolated pools. Fish populations in these tributaries retreated to the New River mainstem or were confined to isolated pools. Flood and drought events reduced or extirpated fish populations in small, high gradient tributaries of NRGNR, and provided an opportunity to examine recolonization of native and nonnative fishes.

Due to limited pre-flood fish distribution data, little was known about the species composition within the tributaries. Recently introduced species typically undergo fast range expansions, but to what extent they use small tributaries in the NRGNR is unclear. Therefore, I hypothesized there would be differences in species order, timing, richness, and abundances (total and relative) between native and nonnative species.

LITERATURE REVIEW

New River Fish Distributions

The New River begins near Blowing Rock, North Carolina, and flows northward 402 km to its confluence with the Gauley River to form the Kanawha River (Wilson and Purvis 2000). The New River drains approximately 17,918 km^2 through the Blue Ridge, Valley and Ridge, and Appalachian Plateau provinces of North Carolina, Virginia and West Virginia, respectively (Stauffer et al. 1995). The New River is unique in that it is surrounded by nine other large river basins. Claytor, Bluestone, and Hawks Nest are three major impoundments on the New River and four smaller dams occur upstream of Claytor Reservoir. An 85 km section of the New River in southern West Virginia is designated as the New River Gorge National River (NRGNR) and has been administered by the National Park Service since 1978.

Cope (1868), Goldsborough and Clark (1908), Addair (1944), Ross and Perkins (1959), and Ross (1959) completed early studies of the New River's fish fauna. Cope (1868) collected from four New River sites in Virginia. Goldsborough and Clarke (1908) collected from less than 10 sites in the West Virginia portion of the New River (Messinger and Chambers 2001). Not until Addair (1944) was there an extensive basin wide survey of the New River. However, these early collections provided a basis for later surveys and distributional histories of the New River's fish fauna by Jenkins et al. (1972), Hocutt et al. (1978, 1979), Hess 1983, Lobb 1986, Neves (1983), Easton et al. (1993), Easton and Orth (1994), Jenkins and Burkhead (1993), Stauffer et al. (1995), Cincotta et al. (1999), Messinger and Hughes (2000), Paybins et al. (2000), Messinger and Chambers (2001), and the West Virginia Division of Natural Resources (WVDNR). These researchers focused on the New River mainstem or large tributaries and attributed the distribution and species composition of the fauna to many factors such as proximity to rich faunas, high gradient, hard bottom, high sulfate levels, spatial differences in geology, water chemistry, stream size, subterranean loss of surface water, water pollution, stream capture, physical barriers, glaciations, and human movement of fishes.

The New River fish fauna is patchily distributed and depauperate with 47 native species (Easton and Orth 1994, Jenkins and Burkhead 1994). The New River system has lower species richness than neighboring drainages and the lowest ratio of species richness to drainage area of the 26 eastern major river drainages (Cincotta et al. 1999). Endemic species known to the New River drainage are *Nocomis platyrhynchus* (bigmouth chub), *Phenacobius teretulus* (kanawha minnow), *Notropis scabriceps* (New River shiner), *Percina gymnocephala* (Appalachia darter), *Etheostoma kanawhae* (kanawha darter), *Etheostoma osburni* (candy darter), and the Bluestone and cave sculpins (Jenkins and Burkhead 1994, Stauffer et al. 1995). The ratio of endemic to native species is second highest to the Mobile drainage (Jenkins and Burkhead 1994).

Species distributions within the New River drainage are influenced by drainage history. The New River follows the course of the ancestral Teays River (Ver Steeg 1945, Janssen 1953). The New River Gorge formed from mountain uplifting and erosion through layers of non-marine shale, sandstone, and limestone and coal of the Mississippian and Pennsylvanian (Swift 2000). The New River Gorge begins near Hinton, WV and extends to the confluence of the New and Gauley Rivers. In several places, the Gorge rim rises more than 300 meters above the river and maximum height is approximately 488 meters (Swift 2000). Geologic processes have created barriers to migration (e.g. Kanawha Falls, Sandstone Falls), powerful rapids, and cascades in the New River Gorge. Such natural barriers have hindered colonization and dispersal and isolated species in the New River system (Neves 1983, McKeown et al. 1984, Jenkins and Burkhead 1994, Messinger and Chambers 2001). The 7.3 m high Kanawha Falls has influenced genetic variation of fishes and number of endemics in the New River (Hocutt et al. 1986). Consequently, separate fish faunas exist above and below Kanawha Falls (Jenkins and Burkhead 1994).

The Teays River, a center of fish evolution and dispersal for the modern Mississippi and Ohio River basins (Ross and Perkins 1959, Jenkins et al. 1972, Hocutt et al. 1978, Neves 1983, McKeown et al. 1984, Hocutt et al. 1986), was altered during the Pleistocene (about two million to eleven thousand years ago). Throughout this age, climate varied between cold glacial and warm interglacial periods and massive glaciers were formed north of the Appalachians. As a result, the Pleistocene glaciers drastically changed the Teays River that was dominant during the Plieocene period (Hocutt et al. 1986). Teays Lake, formed by an ice dam at present day Chillicothe, Ohio, backed up to present day Gauley Bridge, West Virginia (Neves 1983, Lessing 1997). The lake inundated a large portion of the New River Gorge (upstream of Kanawha Falls) and allowed dispersal into the New River drainage (Hocutt et al. 1986). However, extremely cold temperatures may have limited the use of this lake and increased isolation of fishes (Jenkins and Burkhead 1994).

During the last glacial period of the Pleistocene, Appalachian temperatures were cold and dry. Neves (1983) postulated that temperatures extirpated many cold-intolerant species and the upper Teays system served as refugia for cold-water fishes. Jenkins et al. (1972) suggested that these conditions allowed more cool water species to persist and distribute throughout the basin in lower elevations where it is presently uninhabitable by cool water fishes. At one point the *Etheostoma variatum* complex was distributed widely throughout the Teays and Old Mississippi Rivers (McKeown et al. 1984). However, separation and isolation of the ancestral species during the Pleistocene resulted in five separate species (*E. variatum, E. euzonum, E. tetrazonum, E.*

kanawhae, and *E. osburni*). The latter two species (*E. kanawhae* and *E. osburni*) live primarily in separate sections of the modern Kanawha River system, but *E. variatum* has recently expanded its range into the Gauley River, New River Gorge and Greenbrier River.

Further changes to the fish fauna occurred during post-Pleistocene climatic warming. Cool-water species were isolated to relic populations in tributaries by warmer mainstem temperatures. Five endemic species (*Nocomis platyrhyncus*, bigmouth chub; *Phenacobius teretulus*, kanawha minnow; *Notropis scabriceps*, New River shiner; *Percina gymnocephala*, Appalachia darter; *Etheostoma kanawhae* (kanawha darter); *Etheostoma osburni;* candy darter; and the Bluestone and cave sculpins) and the abundant white sucker (*Catostomus commersoni*) prefer cool to cold-water temperatures (Jenkins and Burkhead 1994). Also, a proportionately high number of *Cottus* taxa occur in the New River system (4 *Cottus* to 47 natives). Warm water species (abundant in adjacent drainages) are absent or patchily distributed in the New River system (Jenkins and Burkhead 1994). Jenkins et al. (1972) suggested that warm water species moved downstream in search of warmer water temperatures, but were denied re-entry into the system by Kanawha Falls. Climatic change associated with the Pleistocene period and barriers to migration (e.g. Kanawha Falls) are most likely responsible for the high percentage of endemics and the relatively depauperate New River fish fauna (Neves 1983, Jenkins and Burkhead 1994).

Historically throughout the central Appalachians, stream piracy influenced the inbound and outbound dispersal of fishes into the New River system (Neves 1983, Jenkins et al. 1972, Hocutt et al. 1986, Jenkins and Burkhead 1994). Stream piracy is the geological process of one stream capturing the water of another through erosion. During the Pleistocene, streams had more efficient erosive competency due to higher velocities, which led to a high rate of stream captures

(Ross 1969). Atlantic slope streams captured several headwater streams of the upper Teays River during episodes of stream piracy (e.g. James and Roanoke Rivers). Peripheral populations isolated in Atlantic slope drainages resulted from stream capture, and led to speciation and subsequent dispersal (Neves 1983). Stream piracy events between the New River system and Tennessee and Cumberland drainages have also been suggested (Jenkins and Burkhead 1994). Stream piracy is a natural process. Hence, fishes that enter into new drainages via stream capture should be considered native. Captured streams give up more species than they receive. This may partially account for the depauperate nature of the New River's fish fauna (Hocutt et al. 1986). However, *Phoxinus oreas* (mountain redbelly dace), *Clinostomus funduloides* (rosyside dace), *Ericymba buccata* (silverjaw minnow), and *Etheostoma blennioides* (greenside darter) possibly entered into New River via stream capture (Hocutt et al. 1986, Jenkins and Burkhead 1994).

Fish introductions are common in aquatic systems throughout the United States (Fuller et al. 1999). Many are accidental releases, while others are committed intentionally for forage, bait, or sport (Easton et al. 1993, Jenkins and Burkhead 1994, Cincotta et al. 1999, Fuller et al. 1999). The success of fish species introductions depends on system complexity, number of native species, reproductive success of introduced species, size selection of predators on native and introduced species, and competitive interactions between species (Ross 1991, Moyle and Light 1996). Areas with low species richness and a high availability of resources are often prone to successful fish introductions (Hocutt and Hambrick 1973). Nonnatives impact native species through habitat alterations, disease/parasite introductions, hybridization, trophic alterations, and spatial alterations (Ross 1991).

Current literature lists 89 fish species in the New River system (47 native and 42 introduced). This is the largest number and proportion of introduced species in the eastern and central North American drainages (Jenkins and Burkhead 1994). Based on early surveys by Cope (1868), only five predator species of appreciable size existed in the New River system before introductions: *Anguilla rostrata* (American eel), *Ictalurus punctatus* (channel catfish), *Pylodictis olivaris* (flathead catfish), *Salvelinus fontinalis* (brook trout), and *Lepomis cyanellus* (green sunfish). Jenkins and Burkhead (1994) referenced the Virginia Fish Commission (VFC) as saying that the New River "has in its main stream little else (gamefishes) than the cat fish." Consequently, several game and food fishes have been introduced into the New River. Popular game species introduced by the VFC and WVDNR in the New River system are *Sander vitreum* (walleye), *Oncorhynchus mykiss* (rainbow trout), *Salmo trutta* (brown trout), *Morone chrysops* (white bass), *Morone saxatilis* (striped bass) and *Esox masquinongy* (muskellunge) (Easton and Orth 1994, Jenkins and Burkhead 1994). Three species of bullhead catfishes (*Ameiurus natalis*, yellow bullhead; *Ameiurus nebulosus*,brown bullhead and *Ameiurus melas*, black bullhead) were introduced to portions of the New River drainage (Jenkins and Burkhead 1994). The VFC introduced *Micropterus dolomieu* (smallmouth bass) into New River tributaries in the late 1870's. *Ambloplites rupestris* (rock bass) was also introduced into the New River by the VFC in 1875 (Jenkins and Burkhead 1994). According to surveys conducted by Goldsborough and Clark (1908), *M. dolomieu* and *A. rupestris* quickly expanded their ranges further into West Virginia's portion of the New River. Other game fishes, such as *Lepomis sp*. were probably stocked after black bass. The first available record that Jenkins and Burkhead (1994) have of the *Lepomis macrochirus* (bluegill), the most widely introduced *Lepomis sp*., was in 1936.

Currently, 12 centrarchids occur in the New River drainage, but *Lepomis cyanellus* is native representative in the New River (Jenkins and Burkhead 1994).

Of the non-game fishes in the New River system, nearly half are introduced (Jenkins and Burkhead 1994). *Dorosoma petenense* (threadfin shad) and *Notropis atherinoides* (emerald shiner) were stocked in reservoirs as forage fish (Easton and Orth 1994). Other nonnatives, probably introduced as forage fishes, include *Alosa pseudoharengus* (alewife), *Pimephales promelas* (fathead minnow), and *Labidesthes sicculus* (brook silverside). According to Easton and Orth (1994), private citizens may have introduced *Dorosoma cepedianum* (gizzard shad) into Claytor Reservoir, Virginia. Cincotta et al. (1999), Paybins et al. (2000), and Messinger and Chambers (2001) reported recent range expansions of nonnative species, such as *Cyprinella galactura* (whitetail shiner) and *Notropis telescopus* (telescope shiner) in the New River system. *N. telescopus*, native to the Tennessee River drainage, has occurred in the New River system since 1958 (Jenkins and Burkhead 1994). It was first reported from West Virginia by Hambrick et al. (1973) and has since expanded its range within the New River system (Cincotta et al. 1999). *C. galactura*, also native to the Tennessee River drainage, was first reported for the New River system in 1954 (Ross and Carico 1963, Jenkins and Burkhead 1994). Populations were reported from the mainstem and tributaries of the New River, Virginia, and upper sections of West Virginia (Jenkins et al. 1972, Hess 1983). However, it was not reported from NRGNR until 1988 – 1990 (Easton and Orth 1994). *Phoxinus erthrogaster* (southern redbelly dace), collected from a Gauley River tributary in 2003 (Welsh et al. 2003), represents an addition to the nonnative species list of the New River drainage or waters above Kanawha Falls.

Jenkins and Burkhead (1994) indicate the New River drainage harbors 12 species of darters; four of these species *Etheostoma caeruleum, Etheostoma olmstedi* (tessellated darter), *Etheostoma simoterum* (snubnose darter), and *Percina roanoka,* were considered as introduced or possibly introduced into the New River system. *E. caeruleum* and *P. roanoka* occur within NRGNR; *E. omstedi* the Little River system of North Carolina; and *E. simoterum* Wolf Creek, Virginia, and the upper Bluestone drainage, Viriginia and West Virginia. *P. roanoka* were first collected in the New River drainage in 1963 (Ross 1969, Hocutt and Hambrick 1973) at a site between Claytor Dam and Bluestone Reservoir (Jenkins and Burkhead 1994). In 1970 it was collected for the first time in West Virginia at the mouth of the Greenbrier River and was considered the most abundant darter within 20 river km downstream of Bluestone Dam (Jenkins and Burkhead 1994). *E. caeruleum* are considered as possibly native to portions of the New River (Jenkins and Burkhead 1994, Stauffer et al. 1995). Hocutt and Hambrick (1973) documented the first record from above Kanawha Falls (New River near the mouth of East River). A population of rainbow darters occurred in the lower Gauley system in West Virginia since at least 1976 (Hocutt et al. 1979). The species was considered rare in the New River drainage, Virginia, by Jenkins and Burkhead (1994). The remaining eight darters, including *Etheostoma blennioides*, *Etheostoma flabellare* (fantail darter), *Etheostoma nigrum* (johnny darter), *Etheostoma kanawhae* (Kanawha darter), *Etheostoma osburni, Percina caprodes* (logperch), *Percina gymnocephala,* and *Percina oxyrhynchus* (sharpnose darter) are considered native. Since 1994, two other darter species have been collected from the New River in West Virginia; these species are *Etheostoma variatum* and *Percina maculata* (blackside darter). The variegate darter is native to the Ohio River basin, but was previously absent upstream of Kanawha Falls in the New River drainage (Jenkins and Burkhead 1994). Recent collections, however, documented variegate darter above Kanawha Falls (Cincotta et al. 1999, Messinger and Chambers 2001; data reported herein), adding another introduced species to the list. Most historic records for *Percina maculata* are now recognized as *P. gymnocephala* following the species description of the latter in 1980; Stauffer et al. (1995) indicate *P. maculata* as being present throughout the Gauley River and at the mouth of Piney Creek in NRGNR. Due to recent collections in Gauley (Welsh et al. 2003), which produced only *P. gymnocephala,* the Gauley River records for *P. maculata* may be regarded as *P. gymnocephala* (D. A. Cincotta pers. comm.). However, recently confirmed records of blackside darter within the upper Piney Crek watershed by Cincotta (unpublished data), suggest the Stauffer et al. (1995) record from lower Piney Creek is valid.

Water chemistry and productivity influence fish distributions and success of introduced fishes. Variations occur in water chemistry and productivity among the Blue Ridge, Valley and Ridge, and Appalachian Plateau provinces of the New River basin due to geological differences (Jenkins and Burkhead 1994) and land uses (Paybins et al. 2000). The New River Gorge is inherently unproductive due to sandstone dominated geology and this may partially account for low species abundance in this particular section of the river. Human practices such as coal mining, domestic waste, logging, agriculture, industrial activities, urbanization, and oil/gas extraction have influenced water quality throughout the New River basin (Addair 1944, Messinger and Hughes 2000, Wilson and Purvis 2000). Fecal coliform counts are typically high within smaller tributaries of the NRGNR (Wood 1990, Wilson and Purvis 2000) owing to inadequate sewage treatment plants and untreated sewage inputs. Sewage increases productivity, turbidity, conductivity and fish anomalies, and alters macroinvertebrate and fish community structures. Introduced species are often successful in impaired streams (Herbold and Moyle 1986, Wait and Carpenter 2000), though range expansions of nonnative fishes have coincided with improved water quality over the entire New River basin (Messinger and Chambers 2001).

However, current sizes of native populations may be minimized by previously degraded water quality. The most likely cause of distribution expansion is human movement of fishes throughout the New River system (Easton et al. 1993, Cincotta et al. 1999).

Floods

Characterizing the role of disturbance (i.e. flooding), especially in frequently disrupted lotic systems is needed (Reice et al. 1990). Adequate knowledge of disturbances and recovery of affected systems can aid resource management decision making (Cairns et al. 1971, Hughes et al. 1990, Detenbeck et al. 1992), including, for example, whether or not (or when) to allow systems to naturally recover or be restored by resource managers (Gore et al. 1990, Roghair 2002). Due to their complexity, lotic systems are naturally unstable and are in a constant state of recovery from disturbances (Olmsted and Cloutman 1974, Fisher 1990, Reice et al. 1990).

Disturbances cause systems to deviate from normal conditions (Resh et al. 1988, Niemi et al. 1990). Sousa (1984) defined disturbance as, “a discrete removal of organisms that are subsequently replaced by reproduction of resident survivors or by immigration.” Natural (e.g. droughts and floods) and anthropogenic processes (e.g. pollution, flow regulation, and introduced species) disturb lotic systems, and can kill or remove fishes (Gore et al. 1990). Recovery is the process that returns impacted systems to pre-disturbance levels (Gore et al. 1990, Kelly and Harwell 1990).

Floods and debris flows alter stream habitat, fish assemblages, and fish abundances (Fisher et al. 1982, Dolloff et al. 1994, Matthews 1998). Specifically, flash floods and debris flows remove riparian vegetation, scour streambeds, and drastically alter refuge, foraging, and spawning habitats of fishes. Damage form debris flows (slurries of water, soil, and rocks) exceeds that of floods (Hack and Goodlet 1960, Swanson et al. 1998). Upland streams with high gradients are prone to debris flows during high discharge events (Carling 1988). Timing, frequency, and intensity of floods and debris flows influence long-term affects on fish assemblages. Mortality and migration due to frequent and severe floods cause fish abundances to vary over time (Starrett 1951, Seegrist and Gard 1972, Schlosser 1985, Pearsons et al. 1992, Matthews 1998). Tremendous floods and debris flows appear catastrophic and infrequent, but occur regularly on a geologic time scale and are an important component of lotic systems (Roghair 2002).

Stream habitat complexity plays a role in structuring fish assemblages (Schlosser 1982, Poff and Allan 1995, Frenzel and Swanson 1996), and influences the impacts of floods (Collins et al. 1981, Dolloff 1994). Schlosser (1987) characterized streams as hydraulically complex or hydraulically simple. In general, biotic communities of complex streams are more structured and stable than those of simple streams (Pearsons et al. 1992). Flood intensity is less in complex streams and fishes in hydraulically complex streams have lower probabilities of mortality during floods (Pearsons et al. 1992).

The influence of watershed position and stream gradient on flood impacts may be more important to fish assemblages than habitat complexity (Hanson and Waters 1974, Hoopes 1975, Reice et al. 1990). Headwaters and small drainage basins exhibit high variation in flows owing to small size and low storage capacity (Grossman et al. 1990). In general, hydrologic variability reduces the stability of fish assemblages (Starrett 1951, Moyle and Vondracek 1985, Grossman et al. 1990). Harsh environments, such as steep gradients, increase abiotic control of streams (Grossman et al. 1982, Peckarsky 1983). Fishes in high gradient streams are vulnerable to erosive floods (Fausch and Bramblett 1991, Dolloff et al. 1994), in part, due to a lack of refuge areas. Thus, faunas of high gradient streams are controlled, in part, by abiotic factors such as extreme floods (Roghair 2002). Fast and turbulent flows scour streambeds; hence benthic fishes may be more susceptible to death by floods than pelagic species. Benthic species (e.g. *Cottus bairdi* and *Rhinichthys cataractae*) can be crushed by displaced substrate during floods (Erman et al. 1988). Elwood and Waters (1969) observed high mortality of brook trout from intense flood scouring.

Floods during spawning periods reduce fish populations in small streams (John 1964, Strange et al. 1992). Deposition from floods embeds substrate can eliminate spawning habitats, and smother eggs and larvae (Reice et al. 1990). Conversely, floods can scour streambeds, displacing eggs or larvae. Therefore, fishes that spawn during non-flood seasons increase survival of eggs and larvae. Hanson and Waters (1974) observed that floods in late winter and early spring caused high mortality upon eggs and fry of brook trout (*Salvelinus fontinalis*). Pearsons et al. (1992) demonstrated that summer spawning species (e.g. cyprinids and catostomids) could be severely impacted by spring and summer floods. Species with extended spawning periods (e.g. *Lepomis cyanellus*) can maintain viable populations in flood-prone areas (Ross and Baker 1983). Low abundances of adults in flood-impacted streams may increase spawning success (John 1963, Rinne 1975). Spawning success was documented for green sunfish (*Lepomis cyanellus*), longear sunfish (*Lepomis megalotis*), and species of *Notropis* (Harrel 1978, Harvey 1987) immediately following floods

Floods also chronically influence fish populations. Canopy gaps from girdled, broken, or uprooted trees increase sunlight penetration, stream temperature, primary production, macroinvertebrate abundance, and biomass of streams (Lamberti et al. 1991, Murphy et al. 1986, Keith et al. 1998). Food abundance and lower fish densities increase growth rates of flood survivors and recolonizers (Sousa 1984, Roghair 2000). However, higher stream temperatures may reduce populations of cold-water species.

Floods after spawning periods increase mortality of juvenile fishes. Juvenile fishes have less probability of surviving major disturbances because of poor swimming ability, habitat specificity, and small size. Minnows and sunfish less than 10 mm in length are susceptible to downstream displacement (Harvey 1987). Larger fishes avoid mortality or displacement during flood events through better swimming abilities and use of refuge areas (Fausch and Bramblett 1991).

Historic ecological factors also influence species composition (John 1964, Ross et al. 1985, Matthews 1986, Matthews 1998). Species in unstable streams are normally small, agile, early maturing, and rapid recolonizers with a wide range of physiological tolerances (Fausch and Bramblett 1991). Because floods have impacted fish communities throughout history, species in flood-prone areas lacking these characters have been selected against (Gorman and Karr 1978, Collins et al. 1981, Ross and Baker 1983, Meffe 1984, Moyle and Vondracek 1985). Examples of colonizing fish species are *Ictalurus melas, Pimephales* sp., *Campostoma anomalum, Lepomis cyanellus,* and *Catostomus commersoni* (Grossman et al. 1982, Fausch and Bramblett 1991). Long-term biotic effects of floods should be minimal if fishes are adapted to frequent high discharges (Harrell 1978, Matthews 1998). Meffe and Minckley (1987) suggested that stream fish assemblages are persistent in species present, but vary in abundances following major disturbances.

Drought

Drought can reduce species richness and fish abundances in lotic systems (Wickliff 1945, Starrett 1951, Deacon 1961, Tramer 1977, Matthews 1998). During drought, elevated temperatures and low dissolved oxygen levels increase fish mortality (Tramer 1977, Matthews 1998). Fish mortality during drought conditions was increased due to loss of reliable food supply, increased competition for food, decreased habitat availability, and predation (Paloumpis 1958, Tramer 1977, Ladle and Bass 1981, Griswold et al. 1982, Boulton and Stanley 1995).

Fishes in drought-prone areas also tend to possess characteristics that enhance survival in these conditions. Minckley and Barber (1971) found that the Longfin dace (*Agosia chrysogaster*) seek refuge under algal mats to avoid lethal temperatures of open water. Fishes seek refuge in pools during dry seasons (Wickliff 1945, Paloumpis 1958, Griswold et al. 1982, Capone and Kushlan 1991). Capone and Kushlan (1991) observed that intermediate sized pools with few predators and competitors and complex habitat increased survival of smaller fishes (e.g. cyprinids) during drought. *Etheostoma flabellare* and *Etheostoma spectabile* moved downstream to avoid death in shrinking pools of tributaries (Deacon 1961).

Tramer (1977) observed highest mortalities in fishes with subterminal mouths and no air bladders during a drought in Tenmile Creek, Ohio. Oxygen at the surface of stagnant pools was less accessible and energetically expensive to such species. Due to a broader temperature tolerance, C*yprinella lutrensis* survived dry-season pools better than *Notropis atherinoides* (Paloumpis 1958, Matthews and Manes 1979). Capone and Kushlan (1991) observed that species common to dry-season pools (e.g. *Lepomis cyanellus*) tolerated high temperatures and low oxygen levels.

Recolonization

Recovery of lotic systems involves spatial and temporal components as well as abiotic and biotic processes (Gore et al. 1990). Fish communities have shown resilience following drought (Larimore 1959, Baylor and Osborne 1993), floods (Roghair 2002), and toxic spills

(Olmsted and Cloutman 1974). However, recovery of fish communities is difficult to determine due to their unstable nature (Olmsted and Cloutman 1974).

Determining disturbance recovery is important (Kelly and Harwell1990). Niemi et al. (1990) reviewed >150 studies of systems (both lotic and lentic) recovering from natural or anthropogenic disturbances. The following endpoints were noted: average size of individuals, density, species richness, total biomass, first time of reappearance, and a return to more stable populations. Recovery endpoints were defined as those values believed to rebound to pre-event levels (Niemi et al. 1990). Other endpoints are relative abundance, physiognomy, and life history strategies of impacted organisms (Fisher 1990). Ensign et al. (1997) showed that species richness and abundance are practical endpoints for mobile species with low abundances or clumped distributions as well as for species with moderate to high abundances and random distributions (at the reach scale only for the latter). However, Ensign et al. (1997) determined that only species richness and abundance were appropriate for species with moderate to high abundances and random distributions at the reach-wide scale.

Though fish assemblages are often resilient, recovery times differ among lotic ecosystems and associated fauna. Niemi et al. (1990) observed that recovery ranged from less than a year to more than fifty-two years. Disturbances that had little impact on the surrounding watershed and instream habitat were correlated with the most rapid recovery. The type, severity and length of disturbances are crucial to the recovery of fish assemblages (Olmsted and Cloutman 1974, Niemi et al. 1990). Longest recovery times often occur in physically-altered stream channels and watersheds (Cairns et al. 1971, Cairns 1990, Sedell et al. 1990, Niemi et al. 1990, Yount and Niemi 1990). Olmsted and Cloutman (1974) showed that fish recolonization began within five days after a pesticide spill. Repopulation was quick in the early stages, but gradually decreased in later stages. Matthews (1986) observed drastically altered fish assemblages at badly scoured locations, but fish communities returned to pre-disturbance levels within eight months. Three years after intense flooding in a Virginia stream *S. fontinalis* density and growth rates exceeded pre-flood levels (Roghair 2002). Other studies have found salmonids to be resilient to disturbances (Lamberti et al. 1991, Swanson et al. 1998). The most resilient systems are likely to be the most frequently disturbed (Reice et al. 1990).

The success of disturbed systems and associated species during recovery depends on several abiotic factors. Intense floods transport silts and boulders. Reice et al. (1990) observed slower recovery when both silt and boulders were disturbed and faster recovery when only sand/silt particles were disturbed. As the number of migration barriers (e.g. cascades, waterfalls) increased, recoveries of distressed systems were slowed (Niemi et al. 1990, Ensign et al. 1997).

Fisher (1990) stated that spatial heterogeneity increases an ecosystem's capacity to recover from disturbances. Hence, it is important that streams are comprised of a variety of habitats. For example, pools are of great importance during floods and droughts because they have higher resistance than riffles and runs. Pools are likely to serve as refuge during disturbances such as floods (Fisher 1990) and droughts (Wickliff 1945, Paloumpis 1958, Griswold et al. 1982, Capone and Kushlan 1991).

Recovery times are influenced by location of potential colonizers (Warner and Fenderson 1962, Olmsted and Cloutman 1974, Tramer 1977, Detenbeck et al. 1992, Niemi et al. 1990, Pearsons et al. 1992). Recovery may be seriously comprimised if the majority of organisms in impacted reaches are displaced or killed (Roghair 2002).

Peckarsky (1983) stated that abiotic factors in harsh lotic environments limit the importance of biotic interactions, and Grossman et al. (1982) found that abiotic interactions are important in structuring fish assemblages. Though biotic interactions may have less influence on recovery, their importance should not be underestimated. Floods during spawning periods reduce fish populations in small streams (John 1964, Strange et al. 1992). Deposition from floods embeds substrate and eliminates spawning habitats and eggs/larvae (Reice et al. 1990). Consequently, species requiring specialized spawning habitat might recover slower than fishes with more generalized spawning habitat requirements (Detenbeck et al. 1992). Ensign et al. (1997) observed that fish species with high levels of investment into nesting sites and parental care had more recovery success than those that put forth little effort into parental investment. Recovery times varied among fish reproductive strategies, size at sexual maturity, maximum size and age, and families (Detenbeck et al. 1992).

Fishes in unstable streams (e.g. headwater streams) typically have a wide range of physiological tolerances, are small, agile, and early maturing (Fausch and Bramblett 1991). Consequently, headwater species are very capable of recolonizing disturbed reaches. Cyprinids (minnows) and percids (darters) in headwaters were more capable of surviving environmental extremes such as low and varying dissolved oxygen and pH levels when compared to mainstem fishes (Matthews and Styron 1980). Minnows, darters, and juveniles have shown higher rates of recovery than larger, older individuals (Olmsted and Cloutman 1974, Niemi et al. 1990, Roghair 2002). Juvenile centrarchids (Olmsted and Cloutman 1974) and salmonids (Roghair 2002) have shown more mobility resulting in quicker recovery rates than adults.

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Chapter 2: Ichthyofauna of the New River Gorge National River, West Virginia

ABSTRACT

An understanding of current and historic fish distributions within the New River Gorge National River (NRGNR) is a critical management need for the National Park Service. What is most striking about the New River basin's fish fauna is that nearly one-half of the fish species are nonnative. Previous surveys of the NRGNR fish fauna focused largely on the New River mainstem and larger tributaries, with few efforts on small tributaries within the NRGNR. During 2001-2003 we conducted 84 fish surveys of 36 tributaries in NRGNR to document current distributions and fill information gaps on range expansions of nonnative species. This data combined with previous fish distribution data (as far back as 1928) revealed that 62 fish species and 3 hybrids within or near NRGNR boundaries have been collected. Based on species origins reported in the literature, at least 31 (50%) of these fishes are nonnative. This synthesis of fish distribution data provides managers of the NRGNR with abundance and distribution information concerning native and nonnative fish species, and will be useful for decisions on management of aquatic resources within NRGNR. We recommend long term monitoring programs within NRGNR to document distributional expansion of recently introduced nonnative fishes and status of native fish species.

INTRODUCTION

The New River, a tributary of the Kanawha River, flows northward from headwaters in North Carolina and ends at Kanawha Falls, West Virginia (near the confluence with Gauley River). The New River watershed, approximately 17,918 km^2, includes parts of the Blue Ridge, Valley and Ridge, and Appalachian Plateau (Stauffer et al. 1995). Nine large river basins, several with relatively large fish faunas, surround the New River. Claytor, Bluestone, and Hawks Nest are three major impoundments on the New River and four smaller dams occur upstream of Claytor Reservoir. An 85 km section of the New River in southern West Virginia (below Bluestone Dam) is designated as the New River Gorge National River (NRGNR) and has been administered by the National Park Service since 1978.

Several researchers have studied the fish fauna of the New River within West Virginia, although earliest records and documentation of the native fauna are from Virginia waters (Cope 1868). Goldsborough and Clarke (1908) and Addair (1944) documented fish distributions within the West Virginia portion of the New River. These early collections were supplemented by later accounts by Jenkins et al. (1972), Hocutt et al. (1978, 1979), Hess (1983), Lobb (1986), Neves (1983), Easton et al. (1993), Jenkins and Burkhead (1993), Easton and Orth (1994), Stauffer et al (1995), Cincotta et al. (1999), Messinger and Hughes (2000), Paybins et al. (2000), Messinger and Chambers (2001). The West Virginia Division of Natural Resources (WVDNR) has collected from the New River since the 1950’s. The National Park Service (NPS) in Glen Jean, West Virginia has collected from four sites since 1979. Most collections have occurred on the New River mainstem or in large tributaries.

Jenkins and Burkhead (1993) list 89 fishes from the New River system (47 native and 42 nonnative), including eight endemics. This is the largest number and proportion of nonnative to native species in the eastern and central North American drainages (Jenkins and Burkhead 1994). The New River, with lower species richness than neighboring drainages, has the lowest ratio of native species to drainage area of the 26 eastern major river systems. Stocking programs (and possibly bait-bucket transfers) prior to comprehensive fish surveys in the New River (Cincotta et al. 1999) complicate the understanding of native and nonnative species status (Hocutt et al. 1986). Based on early surveys by Cope (1868), only 4 large piscivorous fishes (*Anguilla rostrata,* American eel; *Ictalurus punctatus,* channel catfish; *Pylodictis olivaris,* flathead catfish; and *Lepomis cyanellus,* green sunfish) existed in the New River system before introductions (Hocutt et al. 1986). *Salvelinus fontinalis* (brook trout) was also in the drainage but was inadvertently left off the Hocutt et al. (1986) list (R. E. Jenkins pers. comm.).

The New River's patchily distributed and depauperate fish fauna (47 native species) and high rate of endemism (eight species) are influenced by drainage history. Barriers from geologic processes (waterfalls, rapids, and cascades) have detained dispersal of fishes and isolated populations (Neves 1983, McKeown et al. 1984, Jenkins and Burkhead 1994, Messinger and Chambers 2001). Fish dispersal and population isolation in the New River system were also influenced by glacial and interglacial periods of the Pleistocene (Jenkins et al. 1972, Neves 1983, McKeown et al. 1984). Stream piracy has influenced the movement of fishes into and out of the New River system (Neves 1983, Jenkins et al. 1972, Hocutt et al. 1986, Jenkins and Burkhead 1992), and may partially explain the depauperate fauna (Hocutt et al. 1986).

The New River Gorge National River was established in 1978 and placed under the direction of the Department of the Interior, National Park Service. Due to the lack of historical data within NRGNR tributaries, the National Park Service needs information on fish distributions for inventory and monitoring purposes. The goal of this study was to provide NPS with an accurate database and a current document of recent and previous fish surveys within NRGNR. To meet this goal, objectives were to:

1. Document the distribution of fishes in perennial tributaries within or near the NRGNR
2. Compile historic and recent fish distribution records from within or near the NRGNR.

METHODS

Study area

The study was conducted within the boundaries of the NRGNR in southern West Virginia (Figure 1). Park boundaries begin just downstream of Hinton and end slightly downstream of Fayette Station. The NRGNR is approximately 85 km long and encompasses 70,000 acres and 77 tributaries. In many places, the gorge rim rises 305 meters above the New River and maximum height is approximately 488 meters. Tributaries typically contained steep gradients, cascades, and waterfalls, with cobble, boulder, or bedrock substrates.

Fish distribution records from within or near NRGNR from over 200 collection sites dating back to 1928 were compiled (Table 1, Figure 2). Thirty-six sites on 26 tributaries within NRGNR during fall 2001 were sampled. Twelve of the 36 sites were re-sampled on three occasions in 2002 (spring, summer, and fall) and once during the spring of 2003 (Table 1). Therefore, a total of 84 collections from 2001 to 2003 were conducted. Primarily, streams were sampled near tributary mouths, but some upstream sites were also sampled.

Fish Collections

A two or three-pass removal method with a DC backpack electrofishing unit at sites on smaller tributaries, whereas a single pass was made on larger tributaries. Fish collections began at the lower end of the sampling reach, and lengths of study sites were approximately 40 times the mean wetted width with a minimum of 150 meters. Pools, runs, and riffles were included in all sampling reaches. In the field, species were identified and measured for total length. Species abundances were recorded for each electrofishing pass. After completing measurements, fishes were released to the approximate capture area, except those preserved for voucher specimens. Specimens, fixed in 10% formalin and preserved in 70% ethanol, were catalogued and shelved at the West Virginia University fish museum.

RESULTS

Between 1928 and 2003, eleven families including 60 species, and two hybrids (*S. fontinalis* x *S. trutta* and *N. rubellus* x *L. albeolus*), were collected within or near the NRGNR boundaries. At least 31 (50%) of the 62 species are nonnative (Jenkins and Burkhead 1994). The following species accounts summarize fish distributions within or near park boundaries of the NRGNR, where site locations are described (Table 1) and mapped (Figures 2 - 61). Numbers listed with each species (under *Species accounts*) correspond to sites in Table 1. Origin for each species is taken primarily from Jenkins and Burkhead (1993).

Species accounts

Clupeidae

Dorosoma cepedianum (LeSueur), gizzard shad. 72, 73, 101, 175. Introduced. Figure 3

Esocidae

Esox masquinongy (Mitchell), muskellunge. 168, 174, 175, 192 . Introduced. Figure 4

Cyprinidae

Campostoma anomalum (Rafinesque), central stoneroller. 3, 4, 9, 10, 16, 18, 23, 33, 35, 37, 43, 55, 58, 59, 60, 61, 70, 71, 73, 76, 77, 79, 81, 82, 86, 87, 91, 92, 96, 98, 100, 101, 103, 104, 106, 107, 108, 110, 111, 112, 115, 117, 120, 121, 122, 125, 126, 127, 128, 130, 132, 134, 147, 148, 152, 153, 154, 155, 156, 159, 163, 164, 166, 167, 169, 170, 171, 172, 173, 176, 177, 178, 179, 182, 184, 185, 186, 187, 188, 189, 191, 194, 195, 196, 197, 201, 204, 205, 206. Native. Figure 5

Clinostomus funduloides (Girard), rosyside dace. 12, 13, 14, 19, 25, 26, 29, 46, 48, 57, 70, 104, 125, 140, 143, 151, 159, 164, 172, 187, 197, 198, 199, 200. Native. Figure 6

Cyprinella galactura (Cope), whitetail shiner. 55, 61, 70, 72, 73, 79, 86, 91, 100, 101, 104, 107, 117, 120, 126, 152, 153, 159, 177, 178, 179, 186, 191. Introduced probably. Figure 7

Cyprinella spiloptera (Cope), spotfin shiner. 6, 8, 20, 43, 62, 70, 72, 73, 74, 79, 80, 83, 84, 85, 86, 91, 99, 100, 101, 102, 105, 126, 153, 154, 167, 170, 171, 173, 177, 179, 180, 182, 184, 190, 191, 194, 195, 201. Native. Figure 8

Cyprinus carpio (Linnaeus), common carp. 7, 43, 68, 154, 174, 179, 180, 194. Introduced. Figure 9

Ericymba buccata (Cope), silverjaw minnow. 3, 4, 8, 16, 20. Native. Figure 10

Erimystax dissimilis (Kirtland), streamline chub. 105. Native. Figure 11

Exoglossum laurae (Hubbs) tonguetied minnow. 68, 175, 188. Native. Figure 12

Luxilus albeolus (Jordan), white shiner. 4, 59, 60, 61, 70, 71, 73, 81, 82, 88, 90, 91, 101, 104, 106, 107, 126, 129, 149, 153, 154, 156, 163, 167, 170, 171, 173, 177, 179, 184, 185, 186, 191, 194. Native but possibly introduced. Figure 13

Luxilus chrysocephalus (Rafinesque), striped shiner. 3, 4, 6, 58, 62, 73, 101, 176, 179, 182, 194, 195. Native but possibly introduced. Figure 14

Nocomis platyrhynchus (Lachner and Jenkins), bigmouth chub. 3, 4, 33, 61, 64, 70, 71, 72, 73, 74, 82, 84, 85, 86, 88, 90, 91, 100, 101, 102, 104, 107, 120, 121, 122, 126, 148, 152, 153, 163, 167, 169, 170, 171, 173, 174, 177, 178, 179, 180, 182, 191, 194. Endemic. Figure 15

Notemigonus crysoleucas (Mitchell), golden shiner. 62, 88, 171, 179, 192, 194. Introduced. Figure 16

Notropis hudsonius (Clinton), spottail shiner. 4, 71, 72, 73, 84, 85, 86, 91, 100, 101, 102, 154, 159, 178, 179, 180, 184, 191. Introduced probably. Figure 17

Notropis photogenis (Cope), silver shiner. 4, 59, 62, 72, 73, 74, 91, 101, 102, 128, 154, 156, 171, 179, 180, 182, 185, 194, 201, 204. Native. Figure 18

Notropis rubellus (Agassiz), rosyface shiner. 3, 4, 43, 59, 60, 61, 72, 73, 74, 82, 84, 90, 91, 99, 100, 101, 102, 126, 128, 148, 152, 153, 156, 159, 171, 173, 176, 177, 178, 179, 180, 184, 191, 195, 201, 204. Native. Figure 19

Notropis scabriceps (Cope), New River shiner. 73, 101, 179, 190, 201, 204. Endemic. Figure 20

Notropis stramineus (Cope), sand shiner. 86, 204. Native. Figure 21

Notropis telescopus (Cope), telescope shiner. 3, 4, 55, 59, 60, 61, 70, 71, 72, 73, 74, 79, 81, 82, 85, 86, 87, 90, 91, 100, 101, 102, 104, 107, 117, 122, 126, 127, 128, 148, 152, 153, 154, 155, 156, 159, 167, 170, 171, 173, 177, 178, 179, 180, 184, 185, 186, 191, 195. Introduced probably. Figure 22

Notropis volucellus (Cope), mimic shiner. 3, 4, 8, 20, 60, 61, 72, 73, 74, 85, 86, 90, 91, 99, 100, 101, 102, 148, 149, 167, 171, 177, 179, 180, 184, 186, 190, 194, 195, 201, 204. Native. Figure 23

Phoxinus oreas (Cope), mountain redbelly dace. 37, 159, 178, 191. Native. Figure 24

Pimephales notatus (Rafinesque), bluntnose minnow. 3, 4, 8, 16, 19, 24, 28, 43, 60, 61, 62, 71, 83, 84, 86, 88, 91, 92, 96, 99, 100, 101, 102, 122, 130, 132, 148, 154, 156, 166, 167, 171, 177, 179, 180, 182, 184, 186, 190, 192, 194, 195, 205, 206. Native but possibly introduced. Figure 25

Pimephales promelas (Rafinesque), fathead minnow. 70. Introduced. Figure 26

Rhinichthys atratulus (Hermann), blacknose dace. 9, 10, 11, 12, 13, 14, 15, 16, 19, 21, 24, 25, 26, 28, 29, 30, 31, 34, 36, 37, 39, 40, 42, 45, 46, 47, 48, 49, 50, 52, 56, 57, 64, 70, 76, 77, 79, 81, 87, 88, 91, 92, 95, 96, 97, 98, 99, 103, 104, 108, 109, 110, 111, 112, 113, 115, 116, 117, 118, 120, 121, 125, 130, 131, 132, 133, 134, 135, 147, 139, 140, 143, 145, 146, 147, 148, 149, 153, 155, 159, 164, 166, 171, 172, 184, 185, 186, 187, 188, 190, 191, 193, 196, 197, 199, 200, 201, 203, 204, 205, 206, 207. Native. Figure 27

Rhinichthys cataractae (Valenciennes), longnose dace. 3, 4, 8, 55, 59, 60, 61, 70, 71, 72, 73, 74, 78, 81, 82, 86, 91, 100, 101, 102, 103, 106, 109, 110, 111, 112, 115, 122, 126, 128, 131, 134, 135, 137, 139, 152, 153, 156, 167, 173, 179, 180, 195, 204. Native. Figure 28

Semotilus atromaculatus (Mitchell), creek chub. 1, 2, 4, 9, 10, 12,13, 14, 15, 16, 17, 19, 20, 21, 24, 25, 26, 28, 19, 30, 31, 34, 35, 37, 38, 39, 40, 41, 42, 43, 45, 46, 48, 51, 53, 57, 59, 64, 67, 70, 73, 75, 77, 79, 83, 84, 87, 88, 89, 91, 92, 93, 95, 96, 98, 103, 104, 107, 108, 109, 110, 111, 112, 114, 115, 116, 117, 118, 119, 120, 121, 125, 126, 128, 130, 132, 133, 135, 137, 139, 140, 143, 145, 146, 147, 151, 152, 153, 155, 157, 159, 161, 162, 164, 166, 172, 176, 180, 185, 186, 187, 188, 189, 190, 191, 193, 194, 196, 197, 198, 199, 200, 202, 203, 204, 205, 206, 207, 210. Native. Figure 29

Catostomidae

Catostomus commersoni (Lacepede), white sucker. 4, 5, 11, 12, 15, 16, 19, 21, 22, 24, 25, 26, 30, 34, 37, 48, 54, 57, 58, 59, 62, 64, 70, 87, 88, 92, 95, 96, 98, 108, 109, 111, 112, 113, 121, 130, 132, 143, 145, 146, 148, 157, 159, 162, 166, 172, 186, 187, 189, 191, 193, 196, 199, 200, 204, 205, 206, 207. Native. Figure 30

Hypentelium nigricans (LeSueur), northern hogsucker. 1, 2, 3, 4, 6, 7, 9, 12, 14, 15, 16, 18, 19, 23, 24, 25, 26, 28, 29, 30, 31, 33, 35, 37, 39, 40, 43, 46, 55, 59, 60, 61, 62, 66, 70, 71, 72, 73, 74, 75, 82, 84, 85, 86, 90, 91, 93, 95, 100, 101, 102, 104, 105, 107, 117, 120, 121, 122, 126, 134, 152, 153, 154, 156, 159, 163, 167, 171, 173, 174, 175, 178, 179, 180, 182, 184, 185, 190, 191, 192, 194, 201, 205, 210. Native. Figure 31

Ictaluridae

Ameiurus natalis, (LeSueur), yellow bullhead. 85, 86, 100, 101, 167, 171, 173, 178, 179, 182, 191. Introduced but possibly native. Figure 32

Ictalurus punctatus (Rafinesque), channel catfish. 3, 7, 8, 32, 43, 83, 85, 86, 93, 100, 101, 105, 174, 178, 179, 182, 183, 192, 194. Native. Figure 33

Pylodictis olivaris (Rafinesque), flathead catfish. 6, 8, 33, 43, 72, 73, 74, 80, 83, 85, 86, 90, 91, 100, 101, 102, 105, 114, 126, 152, 154, 167, 169, 170, 173, 174, 175, 178, 179, 180, 181, 182, 183, 184, 194. Native. Figure 34

Atherinidae

Labidesthes sicculus (Cope), brook silverside. 43, 74, 102, 154, 174, 175, 180, 182. Introduced. Figure 35

Cottidae

Cottus bairdi (Girard), mottled sculpin. 12, 14, 15, 26, 30, 122, 140, 143, 145, 146, 162. Native. Figure 36

Moronidae

Morone chrysops (Rafinesque), white bass. 7, 43, 182, 192, 194. Introduced. Figure 37

Salmonidae

Oncorhynchus mykiss (Walbaum), rainbow trout. 13, 40, 46, 64, 78, 87, 110, 113, 130, 136, 137, 138, 139. Introduced. Figure 38

*Salmo trutta (*Linnaeus), brown trout. 24, 29, 40, 46, 47, 48, 49, 55, 70, 76, 77, 79, 82, 87, 92, 95, 96, 104, 107, 110, 111, 112, 118, 121, 126, 129, 131, 133, 135, 136, 137, 138, 139, 140, 141, 143, 144, 146, 149, 152, 157, 158, 160, 172, 187, 197, 198, 203. Introduced. Figure 39

Salvelinus fontinalis (Mitchell), brook trout. 70, 87, 104, 111, 117, 121, 123, 124, 201. Native. Figure 40

Centrarchidae

Ambloplites rupestris (Rafinesque), rockbass. 4, 6, 7, 8, 9, 16, 18, 19, 22, 23, 24, 29, 37, 43, 54, 55, 60, 61, 62, 64, 70, 71, 72, 73, 74, 82, 85, 86, 90, 91, 92, 96, 100, 101, 102, 105, 107, 117, 121, 122, 126, 132, 151, 152, 153, 154, 155, 157, 163, 165, 167, 169, 170, 171, 173, 174, 175, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 189, 190, 191, 192, 193, 194, 195, 206. Introduced. Figure 41

Lepomis auritus (Linnaeus), redbreast sunfish. 7, 72, 73, 74, 85, 86, 91, 100, 101, 102, 162, 175, 178, 179, 180, 182, 183, 192, 194. Introduced. Figure 42

Lepomis cyanellus Rafinesque, green sunfish. 6, 16, 20, 32, 48, 58, 61, 62, 70, 74, 75, 76, 79, 82, 84, 85, 86, 87, 91, 92, 96, 97, 100, 101, 104, 107, 111, 112, 114, 117, 120, 126, 131, 152, 153, 157, 159, 172, 178, 179, 186, 191, 197. Native. Figure 43

Lepomis gibbosus (Linnaeus), pumpkinseed. 6, 43, 55, 74, 79, 86, 100, 101, 117, 146, 159, 171, 179, 180, 191, 192, 194. Introduced. Figure 44

*Lepomis macrochirus (*Rafinesque), bluegill. 6, 8, 16, 19, 22, 28, 30, 43, 54, 60, 68, 70, 72, 73, 74, 76, 85, 86, 91, 99, 100, 101, 102, 107, 109, 117, 143, 147, 150, 152, 154, 162, 171, 174, 175, 177, 178, 179, 180, 182, 183, 184, 185, 190, 191, 192, 194, 195, 201. Introduced. Figure 45

Lepomis megalotis (Rafinesque), longear sunfish. 73, 85, 86, 100, 101, 102, 174, 175, 177, 179,

194. Introduced. Figure 46

*Micropterus dolomieu (*Lacepede), smallmouth bass. 2, 3, 4, 6, 7, 8, 9, 18, 23, 33, 43, 54, 55, 58, 59, 60, 61, 62, 63, 64, 66, 68, 70, 71, 72, 73, 74, 79, 82, 83, 84, 85, 86, 87, 88, 91, 93, 99, 100, 101, 102, 104, 105, 107, 111, 114, 117, 120, 121, 122, 125, 126, 148, 151, 152, 154, 155, 156, 159, 163, 167, 169, 170, 171, 173, 174, 175, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 190, 191, 192, 194, 201, 210. Introduced. Figure 47

Micropterus punctulatus (Refinesque), spotted bass. 3, 4, 6, 8, 20, 43, 46, 58, 60, 62, 72, 73, 74, 83, 84, 85, 86, 100, 101, 102, 149, 150, 154, 167, 171, 175, 178, 179, 180, 181, 182, 183, 184, 190, 191, 192, 194, 195. Introduced. Figure 48

Micropterus salmoides (Lacepede), largemouth bass. 6, 8, 35, 57, 68, 73, 100, 101, 157, 174, 176, 177, 178, 180, 181, 182, 183, 190, 194, 196. Introduced. Figure 49

Pomoxis annularis Rafinesque, white crappie. 16, 43, 85, 86, 102, 154, 171, 174, 180, 191, 194. Introduced. Figure 50

Pomoxis nigromaculatus (LeSueur), black crappie. 8, 83, 85, 101, 154, 171, 184. Introduced. Figure 51

Percidae

*Etheostoma blennioides (*Rafinesque), greenside darter. 3, 4, 23, 59, 60, 72, 73, 74, 82, 85, 86, 90, 91, 99, 100, 101, 102, 105, 121, 122, 126, 128, 152, 153, 159, 167, 169, 170, 171, 173, 176, 177, 178, 179, 180, 182, 184, 186, 189, 190, 194, 195, 201, 204, 205, 206. Native. Figure 52

*Etheostoma caeruleum (*Storer), rainbow darter. 3, 60, 61, 70, 72, 73, 74, 81, 82, 85, 86, 87, 91, 100, 101, 102, 104, 106, 107, 114, 117, 119, 120, 121, 122, 125, 126, 127, 128, 148, 152, 153, 155, 156, 159, 167, 168, 170, 171, 173, 177, 178, 179, 180, 184, 185, 186, 191. Introduced. Figure 53

*Etheostoma flabellare (*Rafinesque), fantail darter. 2, 14, 15, 21, 23, 24, 25, 26, 28, 29, 64, 87, 88, 92, 95, 96, 99, 101, 106, 108, 109, 110, 111, 112, 113, 115, 126, 131, 132, 135, 137, 147, 148, 149, 162, 172, 187, 188, 189, 193, 197, 201, 204, 205, 206. Native. Figure 54

Etheostoma nigrum (Rafinesque), johnny darter. 8, 56. Native. Figure 55

Etheostoma variatum Kirtland, variegate darter. 61, 73, 91, 101, 107, 120, 121, 122, 126, 127, 152, 153, 159, 177, 179, 186. Introduced. Figure 56

Percina caprodes (Rafinesque), logperch. 3, 4, 7, 55, 72, 73, 74, 85, 86, 91, 100, 101, 102, 174, 175, 180. Native. Figure 57

Percina maculata (Girard), blackside darter. 59, 60, 166, 196, 199, 200. Introduced but possibly native. Figure 58

Percina oxyrhynchus (Hubbs and Raney), sharpnose darter. 3, 8, 33, 43, 59, 60, 72, 73, 74, 82, 85, 86, 90, 91, 100, 101, 102, 105, 122, 126, 129, 169, 170, 180, 182, 184, 190, 194. Native. Figure 59

Percina roanoka (Jordan and Jenkins), Roanoke darter. 59, 60, 61, 71, 72, 73, 74, 85, 86, 90, 91, 100, 101, 102, 126, 127, 128, 152, 153, 156, 167, 169, 170, 171, 173, 178, 179, 180, 184, 185, 186. Introduced probably. Figure 60

Perca flavescens (Mitchell), yellow perch. 43, 154, 179, 182, 192, 194. Introduced. Figure 61

Sander vitreus (Mitchell), walleye. 6, 7, 32, 43, 83, 105, 183, 192. Introduced. Figure 62

Scardinius erythrophthalmus (Linnaeus), European rudd. 179. Introduced. Figure 63

DISCUSSION

Fish introductions are common in aquatic systems throughout the United States (Fuller et al. 1999) and the NRGNR is no exception. Sixty-two species have been collected from within or near the NRGNR. At least 31 (50%) of the 62 species within NRGNR are nonnative (Jenkins and Burkhead 1994), exceeding the estimate of Easton and Orth (1994) between Bluestone Dam and Fayette Station. During recent study, three nonnative species to the New River checklist (i.e., drainages above Kanawha Falls) were added; *Phoxinus erthrogaster* (southern redbelly dace), *Etheostoma variatum* (variegate darter), and *Percina maculata* (blackside darter). The overall high number of nonnatives within the New River drainage has multiple explanations. Several game and forage fishes were introduced by state agencies and citizens (Jenkins and Burkhead 1994, Easton and Orth 1994, Cincotta et al. 1999). Many of these introductions date back to the late 1800s. Bait-bucket introduction is a likely source of most nonnative nongame populations (Cincotta et al. 1999), including species not commonly thought of as baitfish (e.g. darters).

Streams with low numbers of native fishes (Hocutt and Hambrick 1973), occur in close proximity to speciose drainages, and have high impairment (Herbold and Moyle 1986, Wait and Carpenter 2000) often support nonnative species. The New River, naturally depauperate of native fishes, is surrounded by nine large river basins (all potential sources of nonnatives). The New River is impaired by coal mining, domestic waste, logging, agriculture, industrial activities, urbanization, and oil/gas extraction (Addair 1944, Messinger and Hughes 2000, Wilson and Purvis 2000). Range expansions of nonnatives within New River, however, have coincided with water quality improvements throughout the basin (Messinger and Chambers 2001), although current sizes of native populations may be minimized by earlier water quality impairment.

Extirpation and population declines of native species

Comparison of historic and current data on species abundance and presence/absence provides insight into faunal change, but is often confounded by incomparable collection methods or sampling conditions. Herein, faunal change based on available information is discussed.

Populations within or near NRGNR of *Notropis scabriceps, N. stramineus* (sand shiner), *Exoglossum laurae* (tonguetied minnow), and *Phoxinus oreas* (mountain redbelly dace) are small and disjunct. The *N. scabriceps,* a New River endemic, is possibly extirpated from tributaries within NRGNR. In 1935, *N. scabriceps* were collected at three sites within or near NRGNR (Addair 1944; and Addair's records at UMMZ 119243, one specimen from New River 2 miles below Hinton; UMMZ 119256, 17 specimens from Lick Creek; UMMZ 119236 72 specimens from Meadow Creek). The NPS reported New River shiners at three mainstem sites during 1988 – 2001, but no recent collections of New River shiner have been made within tributaries. *N. stramineus* was collected once in 1935 at Lick Creek (Addair 1944, not catalogued at UMMZ) and again within the lower gorge by NPS during sampling between 1988 and 2001. *E. laurea* has a restricted distribution with sites from Wolf Creek, Lick Creek, and the mainstem (1984, 1992, and 1997, respectively; WVDNR unpublished data). *P. oreas* is restricted primarily to watersheds of Brooks Branch, Farley Creek, and Piney Creek.

Populations within or near NRGNR of *Etheostoma nigrum* (johnny darter) and *Erimystax dissimilis* are represented by single locations, with the latter probably extirpated. *E. nigrum* was collected in 1935 from the headwaters of Glade Creek (Addair 1944, UMMZ 118718, n=1) and above Gauley Bridge (Addair 1944, UMMZ 131828), but was absent from other historic or recent sampling locations within or near NRGNR. *E. dissimilis* was collected from the mainstem at Prince in 1935 (Addair 1944, UMMZ 119265, n=4), and its absence from all other New River collections supports extirpation. *E. nigrum, N. scabriceps, E. laurae,* and *P. oreas* often inhabit small streams; hence, larger populations may occur within unsampled headwaters of NRGNR tributaries.

Nonnatives

At least 13 of the 40 nongame species within or near the NRGNR are introduced. Some species were collected at few sites and exhibited patchy distributions (e.g. *Dorosoma cepedianum, Notropis hudsonius* (spottail shiner), *Labidesthes sicculus*); however, most recent data are from tributaries and do not reflect current distributions of all fishes. However, *Cyprinella galactura* (whitetail shiner), *Notropis telescopus* (telescope shiner), *Etheostoma caeruleum* (rainbow darter), *Etheostoma variatum* (variegate darter), and *Percina roanoka* (Roanoke darter) were well represented among the collections, and have exhibited range expansion within NRGNR.

C. galactura is native to the Tennessee River drainage, but researchers have questioned its status in the New River (Jenkins and Burkhead 1994, Stauffer et al. 1995). It was not collected in the New River basin until 1954 in the Virginia portion of the New River (Ross and Carico 1963, Jenkins and Burkhead 1994). These first populations were disjunct and had low abundances. Since the first collections in the New River, the whitetail shiner has exhibited characteristics to that of introduced fishes by rapidly increasing its previously known range and abundance in the New River. It was not collected in the NRGNR until 1988 – 1990 by Easton and Orth (1994). *C. galactura* is currently distributed throughout the entire NRGNR and is more common in the mainstem than in tributaries (but was seasonally abundant in some tributaries within NRGNR during fall 2002 and fall 2003). We expect congeneric competition between the nonnative whitetail shiner and the native spotfin shiner, but the influence of whitetail shiners on spotfin shiner populations is undocumented.

N. telescopus, also native to the Tennessee River drainage, has occurred within the New River system since at least 1958 (Jenkins and Burkhead 1994). This species, first collected from

West Virginia by Hambrick et al. (1973), continues to expand its range in the New River system (Cincotta et al. 1999). The telescope shiner is widely distributed within the NRGNR, but is more common in the mainstem than in tributaries. We expect telescope shiners to compete with other pelagic native minnows, such as *Notropis rubellus* (rosyface shiner) and *Notropis photogenis* (silver shiners), but the influence of *N. telescopus* on native populations is undocumented.

Of eight darter species collected in the NRGNR, three are introduced; rainbow darter *(Etheostoma caeruleum*), variegate darter *(Etheostoma variatum)* and Roanoke darter *(Percina roanoka*) (Jenkins and Burkhead 1994). *Etheostoma caeruleum* (rainbow darter) was considered rare and possibly native to portions of the New River (Jenkins and Burkhead 1994). However, Jenkins and Burkhead (1993) suggested populations have been introduced into the lower Gauley River system in West Virginia and near the East River near the West Virginia – Virginia border. Recent data indicates range expansion of *E. caeruleum* within NRGNR. *E. caeruleum* is currently one of the most widely distributed darters in the NRGNR.

Etheostoma variatum, common in the Ohio River basin, was previously absent above Kanawha Falls in the New River drainage (Jenkins and Burkhead 1994). However, recent collections (Cincotta et al. 1999, Messinger and Chambers 2001, National Park Service unpublished data, data reported herein) indicate the this darter is well established above Kanawha Falls and is distributed widely throughout the length of the NRGNR.

Percina roanoka was first collected in the New River drainage in 1963 (Ross 1969, Hocutt and Hambrick 1973) between Claytor Dam and Bluestone Reservoir. In 1970, it was collected at the mouth of the Greenbrier River, West Virginia, and was considered the most abundant darter within 20 river kilometers downstream of Bluestone Dam (Jenkins and Burkhead 1994). This percid is typically absent from smaller tributaries; hence it is not as widely distributed as *E. caeruleum*. Compiled records indicate that *P. roanoka* is dispersed throughout the mid to upper portions of the NRGNR, mostly in the mainstem.

The New River has eight known endemic fishes: *Nocomis platyrhynchus, Phenacobius teretulus, Notropis scabriceps, Percina gymnocephala, Etheostoma kanawhae, Etheostoma osburni,* and the Bluestone and cave sculpins. Only *Nocomis platyrhynchus* and *Notropis scabriceps* (New River shiner) have been collected in the NRGNR. *Nocomis platyrhynchus* was sporadic in tributaries and common in the New River mainstem. *Notropis scabriceps* appears to be declining within NRGNR based on comparisons between current and historic records. *P. gymnocephala* may have been collected by Stauffer et al. (1995) and reported as *P. maculata;* this record was taken at the mouth of Piney Creek and needs re-examined.

A proportionately high number of *Cottus* taxa occur in the New River (4 *Cottus* to 47 native species). However, mottled sculpin (*Cottus bairdi)* was the only *Cottus* collected in the NRGNR, where it occurs throughout the Manns Creek watershed. Mottled sculpin also occur within Laurel Creek, at Cotton Hill, West Virginia, just downstream of NRGNR boundaries. Considering its extreme limited distribution, this fish may be a relic of the Pleistocene. Cool water species were isolated to relic populations in tributaries by warmer mainstem temperatures during post-Pleistocene climatic warming (Jenkins and Burkhead 1994). Alternatively, *Cottus bairdi* populations in Manns Creek and Laurel Creek drainages were possibly established by bait bucket introduction.

CONCLUSION

The fish fauna of the New River is unique given depauperacy of natives, a high number of nonnatives, and a high number of endemics. The influence of nonnatives on native fishes is an area of concern to the NPS, but actual impacts are undocumented. Further monitoring of native and nonnative fish populations is suggested, but do not recommend efforts for removal of nonnatives. Many of the nonnatives have been well established since the late 1800s, and removal efforts would be unsuccessful given the large size of the New River system. Prevention of additional introductions is unlikely, but educational programs aimed at bait bucket releases may reduce further introductions of nonnatives.

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Table 1. Sites of fish collections within or near the New River Gorge National River (UMMZ denotes records from University of Michigan Museum of Zoology).

SITE	YEAR	STREAM	LOCATION	UTM_EW	UTM_NS	Source
1	1974	PINEY CREEK	SULLIVAN (21.5 MI UPSTREAM FROM MOUTH), NEAR TAKE-IN CREEK	481540	4174080	WVDNR
2	33-35	PINEY CREEK	NEAR COAL CITY, WV	482234	4170301	Addair (1944)
3	1979	KANAWHA RIVER	KANAWHA RIVER JUST BELOW MOUTH OF GAULEY RIVER, GAULEY BRIDGE, WV	482478	4223511	Stauffer field notes
4	1977	NEW RIVER	MAIN CHANNEL NEW RIVER AT MOUTH OF GAULEY R., GAULEY BRIDGE	482668	4223492	Stauffer field notes
5	1981	LITTLE WHITESTICK CR.	0.5 MI UPSTREAM FROM SPRAGUE (1.0 MI UPSTREAM FROM MOUTH)	482800	4182760	WVDNR
6	1963	NEW RIVER	GAULEY BRIDGE (MOUTH OF STREAM)	482860	4223480	WVDNR
7	1978	NEW RIVER	GAULEY BRIDGE - 1.0 MI ABOVE MOUTH	484200	4222480	WVDNR
8	33-35	NEW RIVER	NEW RIVER, JUST UPSTREAM OF CANE BR., GAULEY, WV	484316	4222320	Addair (1944) and UMMZ
9	1997	PINEY CREEK	UPSTREAM OF TOWN OF RALEIGH	484500	4177850	WVDNR
10	1997	WHITESTICK CR.	MOUTH OF STREAM AT TOWN OF RALEIGH	485071	4178582	WVDNR
11	1979	DEMPSEY BRANCH	DEMPSEY BORE HOLE (JUNCTION OF COUNTY RT 8 & RT 8/1) 0.3 MI FROM MOUTH	485720	4211600	WVDNR
12	1983	LAUREL CREEK	STA 1 - 6.2 MI ABOVE MOUTH - DEMPSEY, 140 FT UPSTREAM OF CO RT 8 BRIDGE	485740	4211600	WVDNR
13	1983	LAUREL CREEK	STA 2 - DEMPSEY, 30FT DOWNSTREAM OF MOUTH OF DEMPSEY BR & 6.0 MI ABOVE MOUTH	485800	4211800	WVDNR
14	1983	LAUREL CREEK	STATION 3 - 0.1 MI UPSTREAM OF CASSIDY BRANCH & 5.2 MI ABOVE MOUTH	485900	4212500	WVDNR
15	1978	LAUREL CREEK	1 MI DOWNSTREAM FROM CONFLUENCE WITH DEMPSEY BRANCH (3.7 MI FROM MOUTH)	486060	4212660	WVDNR
16	1979	PINEY CREEK	CONFLUENCE OF PINEY CREEK AND LITTLE BEAVER CK AT US RT 19	486160	4178694	Stauffer field notes
17	1975	DUNLOUP CREEK	MOUNT HOPE (9.0 MI UPSTREAM FROM MOUTH)	486360	4195280	WVDNR
18	1997	PINEY CREEK	UPSTREAM OF BECKLEY STP	486450	4180275	WVDNR
19	1979	LAUREL CREEK	LAUREL CREEK ABOVE AND BELOW OLD MILL AT EXXON STATION AT BECKWITH, WV	486482	4216554	Stauffer field notes
20	1935	LAUREL CREEK	NEAR MOUTH OF JENKINS BR., BECKWITH, WV	486597	4216708	Addair (1944)
21	1973	LAUREL CREEK	1.3 MI ABOVE MOUTH) COUNTY ROUTE 60/11 - JEEP TRAIL	486600	4216740	WVDNR
22	1983	PINEY CREEK	0.5 MI DOWNSTREAM FROM BECKLEY STP	486620	4180460	WVDNR

Table 1. continued

SITE	YEAR	STREAM	LOCATION	UTM_EW	UTM_NS	Source
23	1997	BEAVER CREEK	GLEN MORGAN AT RT 19 BRIDGE	486800	4178300	WVDNR
24	1975	LAUREL CREEK	0.5 MI UPSTREAM FROM BECKWITH (1.0 MI UPSTREAM FROM MOUTH)	486900	4215900	WVDNR
25	1979	LAUREL CREEK	1 MI UPSTREAM FROM MOUTH (SWIMMING HOLE)	486900	4216740	WVDNR
26	1979	LAUREL CREEK	COUNTY 8 BRIDGE AT DEMPSEY - 5.2 MI FROM MOUTH	486920	4215900	WVDNR
27	1978	LAUREL CREEK	0.5 MI UPSTREAM FROM BECKWITH (1 MI UPSTREAM FROM MOUTH)	486920	4215900	WVDNR
28	1975	LAUREL CREEK	0.25 MI UPSTREAM FROM BECKWITH MILL DAM (0.5 MI UPSTREAM FROM MOUTH)	486960	4217600	WVDNR
29	1979	LAUREL CREEK	BECKWITH (IMMEDIATELY DOWNSTREAM FROM MILL DAM - .5 MI ABOVE MOUTH)	486960	4217620	WVDNR
30	1983	LAUREL CREEK	STATION 4 - 3.0 MI ABOVE MOUTH AT THE "SWIMMING HOLE"	487100	4214640	WVDNR
31	1982	DUNLOUP CREEK	4.0 MI ABOVE MOUTH - HIGHWAY BRIDGE IN RED STAR	487160	4198260	WVDNR
32	33-35	NEW RIVER	NEW RIVER AT MOUTH OF LAUREL CR., COTTON HILL, WV	487312	4218365	Addair (1944)
33	1979	NEW RIVER	NEW RIVER, RT 16 BRIDGE, COTTON HILL WV	487373	4218237	Stauffer field notes
34	1975	DUNLOUP CREEK	RED STAR (5.0 MI UPSTREAM FROM MOUTH)	487500	4198460	WVDNR
35	1974	PINEY CREEK	RALEIGH (7.0 MI UPSTREAM FROM MOUTH)	487940	4182380	WVDNR
36	1933	BEAVER CREEK	APPROX. 0.5 MI N OF BLUEJAY, WV	488051	4177537	Addair (1944)
37	1997	LITTLE BEAVER CR.	BEHIND KROGER STORE IN BEAVER	488100	4178000	WVDNR
38	1992	ARBUCKLE CREEK	CHURCH OFF 17/20, DOWNSTREAM OF OAK HILL	488200	4203280	WVDNR
39	1982	DUNLOUP CREEK	4.0 MILES ABOVE MOUTH - HIGHWAY BRIDGE IN RED STAR	488880	4198000	WVDNR
40	1998	DUNLOUP CREEK	4.25 MILES ABOVE THE MOUTH, AT DEWITT JUST ABOVE CAMPGROUND	488906	4197999	WVDNR
41	1933	BEAVER CREEK	APPROX. 1 MI S OF BLUEJAY, WV	488919	4170441	Addair (1944)
42	1982	DUNLOUP CREEK	3.5 MI ABOVE MOUTH - 200 YDS DOWNSTREAM FROM SEWAGE TREATMENT PLANT	489220	4197600	WVDNR
43	1967	NEW RIVER	HAWKS NEST (7.8 MI UPSTREAM FROM MOUTH)	489320	4218700	WVDNR
44	1968	NEW RIVER	HAWKS NEST BELOW POWER PLANT (7.8 MI UPSTREAM FROM MOUTH)	489320	4218700	WVDNR
45	1982	DUNLOUP CREEK	3.5 MILES ABOVE MOUTH - 200 YARDS DOWNSTREAM FROM SEWAGE TREATMENT PLANT	489360	4197520	WVDNR
46	1998	DUNLOUP CREEK	3.25 MILES ABOVE MOUTH, 700FT BELOW MOUTH OF BARREN RUN	489775	4197628	WVDNR

Table 1. continued

SITE	YEAR	STREAM	LOCATION	UTM_EW	UTM_NS	Source
47	1990	FAT CREEK	1.5 MILES ABOVE THE MOUTH	489840	4184600	WVDNR
48	2001	DUNLOUP CREEK	APPROXIMATELY 2 KM SW OF THURMOND, WV	490273	4198129	Welsh field notes
49	1982	FAT CREEK	MOUTH OF BRAMMER BRANCH (2.5 MI UPSTREAM FROM MOUTH)	490620	4182980	WVDNR
50	1975	FAT CREEK	MOUTH OF CYCLONE HOLLOW (3.0 MI UPSTREAM FROM MOUTH)	490900	4183040	WVDNR
51	1964	DUNLOUP CREEK	(2 MI UPSTREAM FROM MOUTH) 4 MI BELOW GLEN JEAN	490900	4198300	WVDNR
52	1997	FAT CREEK	APPROX. 100M UPSTREA OF CONFLUENCE WITH BRAMMER BRANCH	491017	4182855	Welsh field notes
53	2001	ARBUCKLE CREEK	APPROX 1.9 KM SE OF MINDEN,WV	491301	4202233	Welsh field notes
54	1983	MILL CREEK	ANSTED - 2 MI UPSTREAM FROM MOUTH	491400	4220200	WVDNR
55	1998	PINEY CREEK	AT RR MARKER3, 1.5 MILES ABOVE MOUTH, 0.75 MILES BELOW MOUTH OF FAT CREEK	491404	4187397	WVDNR
56	1933	GLADE CREEK	HEADWATERS, NEAR COOL RIDGE, WV	491593	4165685	Addair (1944)
57	2001	MARR BRANCH	APPROXIMATELY 2 KM NE OF FAYETTEVILLE, WV, ALONG RT. 82.	491638	4213825	Welsh field notes
58	1964	PINEY CREEK	0.3 MI UPSTREAM FROM MOUTH	491740	4188520	WVDNR
59	1979	PINEY CREEK	PINEY CREEK, ST RT 41 BRIDGE AT MOUTH AT MCCREERY WV	491767	4188862	Stauffer field notes
60	1979	NEW RIVER	MAIN CHANNEL NEW RIVER AT MOUTH OF PINEY CREEK	491802	4188996	Stauffer field notes
61	2001	PINEY CREEK	AT MOUTH NEAR MCCREERY, WV.	491804	4188962	Welsh field notes
62	1964	NEW RIVER	MCCREEDY (NEAR PINEY CREEK), 38.0 MI UPSTREAM FROM MOUTH	491880	4189040	WVDNR
63	1999	NEW RIVER	POOL IMMEDIATELY UPSTREAM OF MOUTH OF PINEY CREEK	491995	4188931	WVDNR
64	1982	MILL CREEK	THREE MI UPSTREAM FROM THE MOUTH	492140	4219500	WVDNR
65	1976	MILL CREEK	COUNTY ROUTE 5/1 BRIDGE (3.0 MI UPSTREAM FROM MOUTH)	492140	4219500	WVDNR
66	1998	DUNLOUP CREEK	1.O MILE ABOVE MOUTH, ABOVE BRIDGE AT TRAIL HEAD PARKING AREA	492287	4199323	WVDNR
67	1935	WOLF CREEK	1 MILE E OF FAYETTEVILLE	492291	4210431	Addair (1944)
68	1984	WOLF CREEK	2.5 MI ABOVE MOUTH	492300	4210000	WVDNR
69	1984	WOLF CREEK	FAYETTEVILLE WATER IMPOUNDMENT (2.5 MILES ABOVE MOUTH)	492300	4210000	WVDNR
70	01-03	MARR BRANCH	AT MOUTH TO ~150 M UPSTREAM APROXIMATELY 2 KM NNW OF SOUTH FAYETTE, WV	492431	4214287	David Wellman
71	2001	ARBUCKLE CREEK	AT MOUTH ACROSS NEW RIVER FROM THURMOND	492453	4201454	Welsh field notes

Table 1. continued

SITE	YEAR	STREAM	LOCATION	UTM_EW	UTM_NS	Source
72	88-90	NEW RIVER	61.5 RKM DOWNSTREAM OF BLUESTONE DAM	492610	4201351	Easton and Orth 1994
73	88-01	NEW RIVER	61.5 RKM DOWNSTREAM OF BLUESTONE DAM	492610	4201351	J. Purvis - NPS
74	1984	NEW RIVER	61.5 RKM DOWNSTREAM OF BLUESTONE DAM	492610	4201351	M. D. Lobb 1986
75	1974	LITTLE BEAVER CR.	500 FT DOWNSTREAM FROM LITTLE BEAVER LAKE (3.5 MI UPSTREAM FROM MOUTH)	492840	4178500	WVDNR
76	01-03	WOLF CREEK	ABOVE MOUTH NEAR SOUTH FAYETTE, WV	492891	4211943	Welsh field notes
77	1979	WOLF CREEK	0.1 MI ABOVE MOUTH (NEAR CONFLUENCE WITH NEW RIVER)	492960	4212900	WVDNR
78	1959	WOLF CREEK	(0.5 MI UPSTREAM FROM MOUTH)	492980	4212180	WVDNR
79	2002	WOLF CREEK	AT MOUTH NEAR SOUTH FAYETTE, WV BY CR 82	493017	4212960	David Wellman
80	33-35	NEW RIVER	NEW RIVER AT MOUTH OF WOLF CR., SOUTH FAYETTE, WV	493029	4212994	Addair (1944)
81	1982	DUNLOUP CREEK	0.25 MI ABOVE MOUTH - OLD RAILROAD BRIDGE NEAR THURMOND WV	493040	4199920	WVDNR
82	2001	DUNLOUP CREEK	AT MOUTH APPROXIMATELY 1 KM SSE OF THURMOND, WV	493177	4200490	Welsh field notes
83	1935	NEW RIVER	NEW RIVER AT THURMOND R.R. STATION	493210	4200632	Addair (1944)
84	1979	NEW RIVER	OLD RT 82 BRIDGE AREA AT BEACH AT FAYETTE STATION UNDER RT 19 BRIDGE	493225	4212779	Stauffer field notes
85	88-90	NEW RIVER	91.5 RKM DOWNSTREAM OF BLUESTONE DAM UPSTREAM OF WOLF CREEK	493272	4212713	Easton and Orth 1994
86	88-01	NEW RIVER	91.5 RKM DOWNSTREAM OF BLUESTONE DAM UPSTREAM OF WOLF CREEK	493272	4212713	J. Purvis - NPS
87	2003	MILL CREEK	BRIDGE ON COUNTY ROUTE 5/1 (6.5 MI UPSTREAM FROM THE MOUTH)	493600	4215340	WVDNR
88	1979	MILL CREEK	MILL CREEK AT COUNTY ROUTE 5 BRIDGE IN AMES HEIGHT WV	493959	4214905	Stauffer field notes
89	01-03	FERN CREEK	AT MOUTH TO 150 M UPSTREAM, APPROXIMATELY 3.2 KM EAST OF FAYETTEVILLE, WV	493967	4211935	David Wellman
90	1979	NEW RIVER	AT BEACH AREA ON LEFT SHORE UPSTREAM OF STONE CLIFF BRIDGE	494411	4198321	Stauffer field notes
91	1997	NEW RIVER	MAIN CHANNEL AT STONECLIFF	494471	4198328	USGS
92	1997	GLADE CREEK	UPSTREAM OF 5TH CROSSING DOWNSTREAM FROM BECKLEY WATER PLANT	494500	4176000	WVDNR
93	33-35	NEW RIVER	NEW RIVER AT MOUTH OF DOWDY CREEK	494543	4192537	Addair (1944)
95	1979	MILL CREEK	2.5 MI ABOVE MOUTH (0.5 MI UPSTREAM FROM US RT 19)	494600	4214420	WVDNR
96	1997	GLADE CREEK	300 YARDS UPSTREAM OF 3RD CROSSING DOWNSTREAM FROM BECKLEY WATER PLANT	495000	4174400	WVDNR

Table 1. continued

SITE	YEAR	STREAM	LOCATION	UTM_EW	UTM_NS	Source
97	2001	FERN CREEK	AT RT. 82 BRIDGE AT EDMUND, WV	495095	4212452	Welsh field notes
98	1996	GLADE CREEK	APPROX. 0.5 MI DOWNSTREAM OF BECKLEY WATER COMPANY DAM	495227	4173012	Welsh field notes
99	1935	MILL CREEK	NEAR MOUTH	495304	4186784	Addair (1944)
100	88-90	NEW RIVER	41.5 RKM DOWNSTREAM OF BLUESTONE DAM	495305	4189820	Easton and Orth 1994
101	88-01	NEW RIVER	41.5 RKM DOWNSTREAM OF BLUESTONE DAM	495305	4189820	J. Purvis - NPS
102	1984	NEW RIVER	41.5 RKM DOWNSTREAM OF BLUESTONE DAM	495305	4189820	M. D. Lobb 1986
103	1975	GLADE CREEK	0.5 MI UPSTREAM FROM MOUTH OF PINCH CREEK (6.0 MI UPSTREAM FROM MOUTH)	495380	4179300	WVDNR
104	01-03	MILL CREEK	AT MOUTH TO ~150 M UPSTREAM APPROX. 1.7 KM NNE OF GRANDVIEW	495496	4187056	David Wellman
105	1935	NEW RIVER	NEW RIVER AT PRINCE	495698	4189166	Addair (1944)
106	1979	LAUREL CREEK	LAUREL CREEK FROM RR BR TO MOUTH, OFF FAYETTE CO RT 41/27 AT QUINNIMONT WV	495806	4189136	Stauffer field notes
107	2001	LAUREL CREEK	AT MOUTH APPROXIMATELY 0.4 KM SW OF QUINNIMONT, WV.	496017	4189164	Welsh field notes
108	1933	GLADE CREEK	NEAR SHADY SPRING	496190	4179491	Addair (1944)
109	1991	PINCH CREEK	250 FT UPSTREAM OF MOUTH	496200	4179420	WVDNR
110	2001	GLADE CREEK	FROM INTERSTATE 64 BRIDGE (ABOVE FALLS) TO MOUTH OF PINCH CREEK.	496277	4179577	Welsh field notes
111	2002	GLADE CREEK	NEAR I-64 BRIDGE	496277	4179577	WVDNR
112	2001	PINCH CREEK	APPROXIMATELY 200 M ABOVE MOUTH APPROXIMATELY 2.9 KM E OF CROW, WV.	496456	4179204	Welsh field notes
113	1975	MILL CREEK	CO. RT. 5/3 CROSSING NEAR THE HEADWATERS (7.5 MI UPSTREAM FROM THE MOUTH)	496480	4214440	WVDNR
114	01-03	SHORT CREEK	AT MOUTH APPROXIMATELY 1.5 KM E OF KAYMOOR, WV	496790	4211190	Welsh field notes
115	1975	GLADE CREEK	0.25 MI UPSTREAM FROM MOUTH OF KATES BRANCH (5.0 MI UPSTREAM FROM MOUTH)	496800	4180540	WVDNR
116	01-03	COAL RUN	AT CUNARD/KAYMOOR TRAILHEAD NEAR CUNARD, WV	496883	4205595	Welsh field notes
117	01-03	SLATER CREEK	AT MOUTH TO ~150 M UPSTREAM AT THAYER, WV	497106	4194698	David Wellman
118	2001	KEENEYS CREEK	AT MOUTH NEAR KEENEYS CREEK, WV	497436	4209552	Welsh field notes
119	01-03	FIRE CREEK	AT MOUTH TO ~160 M UPSTREAM, APPROXIMATELY 4.7 KM EAST OF THURMOND, WV	497540	4200800	David Wellman
120	01-03	COAL RUN	AT MOUTH TO ~ 150 M APPROXIMATELY 0.5KM NNE OF CUNARD, WV	497783	4206349	David Wellman
121	01-03	BUFFALO CREEK	AT MOUTH TO ~205 M UPSTREAM APPROXIMATELY 2 KM NNE OF THAYER, WV	497821	4195838	David Wellman

Table 1. continued

SITE	YEAR	STREAM	LOCATION	UTM_EW	UTM_NS	Source
122	2001	MANNS CREEK	AT MOUTH APPROXIMATELY 0.4 KM N OF SEWELL, WV	498201	4205637	Welsh field notes
123	1996	BUFFALO CREEK	0.4 MILES ABOVE THE MOUTH AT ROAD CROSSING	498206	4196117	WVDNR
124	1997	BUFFALO CREEK	0.4 MILE ABOVE THE MOUTH AT ROAD CROSSING	498300	4196200	WVDNR
125	01-03	EPHRIAM CREEK	AT MOUTH TO ~184M UPSTREAM, APPROXIMATELY 3.8 KM SOUTH OF SEWELL, WV	498428	4201676	David Wellman
126	2001	GLADE CREEK	AT MOUTH APPROXIMATELY 1 KM W OF GLADE, WV.	498876	4186662	Welsh field notes
127	2002	GLADE CREEK	AT MOUTH ~50 M UPSTREAM. AT NPS GLADE CREEK CAMP GROUND	498885	4186652	David Wellman
128	1979	GLADE CREEK	GLADE CREEK AT MOUTH ALONG CO RD PARALLELLING NEW RIVER	498944	4186676	Stauffer field notes
129	1995	PINCH CREEK	PINCH CREEK	499115	4176352	WVDNR
130	1979	PINCH CREEK	3.5 MI ABOVE MOUTH (.5 MI BELOW COUNTY RT 22 BRIDGE)	499160	4177180	WVDNR
131	1996	GLADE CREEK	STA 1, 0.6 MI ABOVE THE MOUTH 100 YDS ABOVE THE FALLS (PAST BEDROCK PORTION)	499200	4185900	WVDNR
132	1979	GLADE CREEK	2 MI BELOW BECKLEY WATER CO DAM, 0.9 MI ABOVE MOUTH	499360	4185460	WVDNR
133	1992	KEENEY CREEK	1 MILE UPSTREAM OF MOUTH	499500	4209500	WVDNR
134	1935	LAUREL CREEK	NEAR TOWN OF LAUREL CREEK, WV	500566	4189745	Addair (1944)
135	1985	LAUREL CREEK	WV ROUTE 41 BRIDGE (LAYLAND) (3.5 MILES ABOVE MOUTH)	500580	4189740	WVDNR
136	1996	LAUREL CREEK	STA 1,4.0 MAM, APPROX 1.25 MI BELOW UPPER RT 41 BRIDGE	501200	4190000	WVDNR
137	1996	LAUREL CREEK	STA 4, 5.25 MILES ABOVE THE MOUTH IMMEDIATELY BELOW UPPER RT 41 CROSSING	502200	4191500	WVDNR
138	1991	LAUREL CREEK	RT 41 BRIDGE UPSTREAM 100 YDS	502220	4191500	WVDNR
139	1996	LAUREL CREEK	STA 3, 4.75 MILES ABOVE THE MOUTH, 0.5 MILES BELOW UPPER RT 41 CROSSING	502230	4191561	WVDNR
140	1996	CHESTNUT KNOB FORK	50 FEET ABOVE MOUTH	502300	4191600	WVDNR
141	2001	MANNS CREEK	BELOW CONFLUENCE OF GLADE CREEK, E OF SEWELL, WV	502306	4204784	Welsh field notes
142	1982	GLADE CREEK	1.0 MI ABOVE MOUTH AT END OF TRAM GRADE	504200	4204240	WVDNR
143	2001	GLADE CREEK	AT BABCOCK STATE PARK, WV	504501	4203839	Welsh field notes
144	1982	GLADE CREEK	2.2 MI ABOVE MOUTH (AT MOUTH OF DAVIS BRANCH)	504600	4202800	WVDNR
145	1979	GLADE CREEK	GLADE CREEK AT CO RT 19/33 BRIDGE	504648	4202986	Stauffer field notes

Table 1. continued

SITE	YEAR	STREAM	LOCATION	UTM_EW	UTM_NS	Source
146	1982	GLADE CREEK	2.0 MI ABOVE MOUTH (400 FT DOWNSTREAM OF COUNTY RT 19/33 BRIDGE)	504660	4203100	WVDNR
147	1979	MADAM CREEK	MADAM CREEK AT CO RT 3/21 BRIDGE	506148	4169579	Stauffer field notes
148	1979	MADAM CREEK	MADAM CREEK AT CO RT 3/21 BRIDGE, HINTON WV BELOW FALLS	506160	4169572	Stauffer field notes
149	1992	FALLS BRANCH	1/4 MILE UPSTREAM OF MOUTH	506300	4177640	WVDNR
150	1935	MEADOW CREEK	MEADOW CREEK AT MOUTH, AT MEADOW CREEK, WV	506433	4184587	Addair (1944)
151	2001	SEWELL BRANCH	AT MOUTH APPROXIMATELY 0.9 KM SSW OF MEADOW CREEK, WV	506489	4183703	Welsh field notes
152	2001	MEADOW CREEK	AT MOUTH NEAR MEADOW CREEK, WV.	506490	4184611	Welsh field notes
153	2001	MEADOW CREEK	AT MOUTH NEAR MEADOW CREEK, WV	506490	4184611	WVDNR
154	1979	NEW RIVER	ALONG SHORELINE UPSTREAM OF MOUTH OF MEADOW CREEK, MEADOW CREEK WV	506499	4184478	Stauffer field notes
155	2001	FALLS BRANCH	AT MOUTH APPROXIMATELY 3.5 KM SW OF SANDSTONE, WV.	506611	4177487	Welsh field notes
156	1979	MEADOW CREEK	MEADOW CREEK FROM MOUTH UPSTREAM TO RAILROAD BRIDGE MEADOW CREEK, WV	506646	4184848	Stauffer field notes
157	1997	MANNS CREEK	9.26 MILES ABOVE MOUTH NEAR INT OF ST RT 10	507114	4207012	WVDNR
158	1985	SMOKY BRANCH	STA 1 - 0.5 MILE UPSTREAM FROM THE MOUTH	507160	4198100	WVDNR
159	01-03	FARLEYS CREEK	DOWNSTREAM OF I-64 BOX CULVERT, APPROX. 2 KM SSE OF MEADOW CK, WV	507281	4181829	David Wellman
160	1985	SMOKY BRANCH	STA 2 - 1 MILE UPSTREAM FROM MOUTH	507340	4197520	WVDNR
161	1972	BURNT CREEK	0.25 MI UPSTREAM FROM MOUTH) JUST ABOVE ROUTE 41	507460	4197160	WVDNR
162	1985	SMOKY BRANCH	STA 3 - .25 MILE DOWNSTREAM FROM WV ROUTE 41 (1.25 MILES ABOVE MOUTH)	507780	4197420	WVDNR
163	1979	NEW RIVER	MAIN CHANNEL NEW RIVER AT SANDSTONE FALLS	508136	4178717	Stauffer field notes
164	1968	MEADOW CREEK	1.2 MI ABOVE MEADOW CREEK POST OFFICE (1.8 MI UPSTREAM FROM MOUTH)	508460	4186500	WVDNR
165	1972	GLADE CREEK	BRIDGE CROSSING 2 MI ABOVE DANESE (6.75 MI UPSTREAM FROM MOUTH)	508480	4198880	WVDNR
166	1983	MEADOW CREEK	STATION 3 - BEURYTOWN (2.0 MI UPSTREAM FROM MOUTH)	508500	4186560	WVDNR
167	1979	NEW RIVER	NEW RIVER 6.8 ROAD MILES DOWNSTREAM OF MADAM CREEK	508759	4178940	Stauffer field notes
168	2003	NEW RIVER	I-65 BRIDGE AT SANDSTONE	508819	4181275	WVDNR
169	1979	NEW RIVER	MAIN CHANNEL NEW RIVER 1.5 ROAD MILES DOWNSTREAM OF MADAM CREEK AT ISLAND	509128	4168486	Stauffer field notes

Table 1. continued

SITE	YEAR	STREAM	LOCATION	UTM_EW	UTM_NS	Source
170	1979	NEW RIVER	NEW RIVER 'ISLAND STATION' DOWNSTREEAM ABOUT 0.75 ROAD MILE FROM MADAM CR.	509158	4168504	Stauffer field notes
171	1979	NEW RIVER	MAIN CHANNEL NEW RIVER JUST BELOW MOUTH OF MEADOW CREEK AT HINTON, WV	509178	4169266	Stauffer field notes
172	1998	MEADOW CREEK	2.5 MILES ABOVE THE MOUTH, AT CONFLUENCE OF LEFTHAND FORK	509182	4187180	WVDNR
173	1979	NEW RIVER	MAIN CHANNEL NEW RIVER AT MOUTH OF MADAM CREEK	509201	4169314	Stauffer field notes
174	1992	NEW RIVER	POOL AT LAUREL CREEK BRIDGE	509300	4179900	WVDNR
175	1997	NEW RIVER	LAUREL CREEK POOL	509300	4180065	WVDNR
176	1953	LICK CREEK	NEAR SANDSTONE ON WV 20	509325	4180847	WVDNR
177	2001	LICK CREEK	AT MOUTH APPROXIMATELY 1 KM N OF SANDSTONE, WV	509327	4180885	Welsh field notes
178	88-90	NEW RIVER	16.5 RKM DOWNSTREAM OF BLUESTONE DAM JUST UPSTREAM OF SANDSTONE FALLS	509333	4180197	Easton and Orth 1994
179	88-01	NEW RIVER	16.5 RKM DOWNSTREAM OF BLUESTONE DAM JUST UPSTREAM OF SANDSTONE FALLS	509333	4180197	J. Purvis - NPS
180	1984	NEW RIVER	16.5 RKM DOWNSTREAM OF BLUESTONE DAM JUST ABOVE SANDSTONE FALLS	509333	4180197	M. D. Lobb 1986
181	1963	NEW RIVER	HINTON - 61.0 MI UPSTREAM FROM MOUTH	509340	4169240	WVDNR
182	1966	NEW RIVER	8.2 MI BELOW HINTON - 55.5 MI UPSTREAM FROM MOUTH	509360	4180160	WVDNR
183	2000	NEW RIVER	POOL AT MOUTH OF LAUREL CREEK	509390	4180416	WVDNR
184	1979	NEW RIVER	MAIN CHANNEL NEW RIVER AT MOUTH OF LAUREL CREEK AT SANDSTONE WV	509400	4180065	Stauffer field notes
185	1979	LAUREL CREEK	LAUREL CREEK AT MOUTH TO 200' ABOVE FIRST RIFFLE	509486	4180026	Stauffer field notes
186	2001	LAUREL BRANCH	AT MOUTH NEAR SANDSTONE, WV	509546	4180035	Welsh field notes
187	2001	MEADOW CREEK	NE OF MEADOW CREEK, WV	509570	4187282	Welsh field notes
188	1992	LICK CREEK	1/2 MILE UPSTREAM OF MOUTH	509600	4181600	WVDNR
189	1968	LICK CREEK	1/2 MI ABOVE SANDSTONE - 0.5 MI UPSTREAM FROM MOUTH	509620	4181500	WVDNR
190	3195	NEW RIVER	NEW RIVER, 2 MI BELOW HINTON	509688	4172610	Addair (1944)
191	01-03	BROOKS BRANCH	AT MOUTH NEAR BASS LAKE, BARKSDALE, WV	509814	4173314	Welsh field notes
192	1969	NEW RIVER	BELOW BRIDGE BELOW BLUESTONE DAM (63.5 MI UPSTREAM FROM MOUTH)	509900	4167000	WVDNR
193	1975	MEADOW CREEK	MEADOW BRIDGE (3.0 MI UPSTREAM FROM MOUTH)	509940	4187440	WVDNR
194	1970	NEW RIVER	BLUESTONE DAM TO MOUTH OF GREENBRIER RIVER - 63.5 MI UPSTREAM FROM MOUTH	510120	4166500	WVDNR

Table 1. continued

SITE	YEAR	STREAM	LOCATION	UTM_EW	UTM_NS	Source
195	1974	GREENBRIER RIVER	MOUTH OF GREENBRIER RIVER, HINTON, WV, RT 3 BRIDGE	510188	4167082	Stauffer field notes
196	1983	MEADOW CREEK	STATION 2 - CLAYPOOL (4.0 MI UPSTREAM FROM MOUTH)	511160	4187340	WVDNR
197	1998	MEADOW CREEK	4 MILES ABOVE THE MOUTH, 100YRDS BELOW MOUTH OF CLAYPOOL BRANCH	511193	4187343	WVDNR
198	2001	MEADOW CREEK	AT RT. 24 BRIDGE S OF MEADOW BRIDGE, WV.	512352	4189074	Welsh field notes
199	1983	MEADOW CREEK	0.5 MI UPSTREAM FROM MEADOW BRIDGE (7 MI UPSTREAM FROM MOUTH)	512560	4190700	WVDNR
200	1983	MEADOW CREEK	STATION 1 - 0.5 MI UPSTREAM FROM MEADOW BRIDGE (7 MI UPSTREAM FROM MOUTH)	512580	4190700	WVDNR
201	1935	MEADOW CREEK	CA 5 MI ABOVE MOUTH	512722	4189955	Addair (1944)
202	1972	GLADE CREEK	(8.5 MI UPSTREAM FROM MOUTH)-ALONG SECOND RT 60/16 APPROX 2 MI SO OF RT 60	513200	4201160	WVDNR
203	1976	GLADE CREEK	COUNTY ROUTE 41/7 BRIDGE (10.0 MI UPSTREAM FROM MOUTH)	513840	4202040	WVDNR
204	1935	LICK CREEK	NEAR GREEN SULPHUR SPRINGS, WV	515678	4183904	Addair (1944)
205	1979	LICK CREEK	LICK CREEK JUST ABOVE CONFLUENCE WITH MILL CREEK ALONG CO RT 4	516296	4184066	Stauffer field notes
206	1979	MILL CREEK	MILL CREEK CO RT 4 BRIDGE AT GREEN SULPHUR SPRINGS	516587	4183549	Stauffer field notes
207	1928	DUNLOUP CREEK	NEAR GLEN JEAN - MAY BE SAME AS ADDAIR, BUT ADDAIR LISTED NO FISH	486954	4197782	UMMZ (Hubbs and Hubbs)
208	33-35	DUNLOUP CREEK	DUNLOUP CREEK, LISTED AS LITTLE LOOP CR. [NEAR GLEN JEAN]	486954	4197782	Addair (1944)
209	33-35	PINEY CREEK	NEAR FITZPATRICK, WV	481559	4176996	Addair (1944) and UMMZ
210	1935	PINEY CREEK	CA 1 MI BELOW WRIGHT	491553	4188290	Addair (UMMZ)

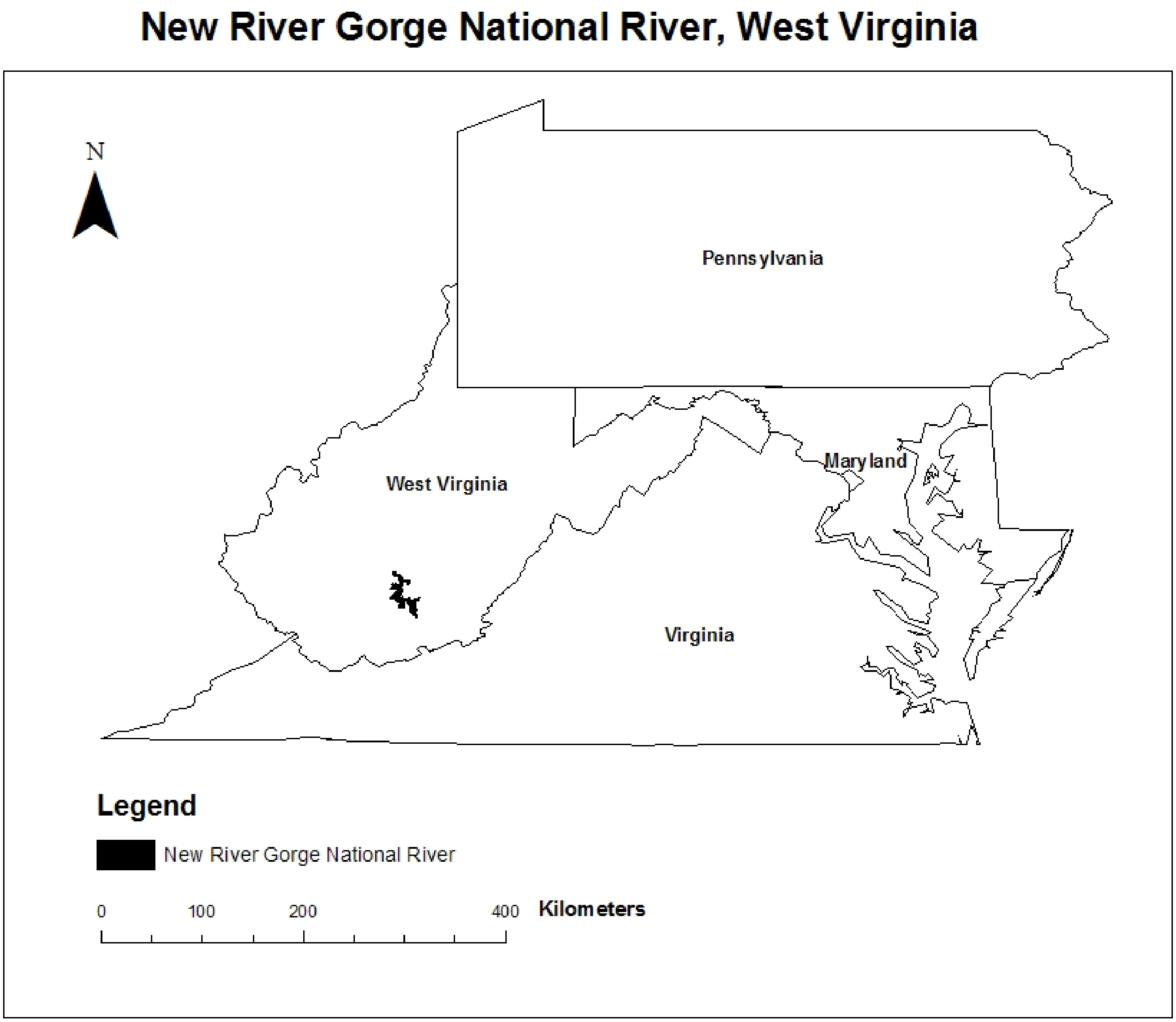

Figure 1. Location of New River Gorge National River in southern West Virginia.

Fish Collection Sites from 1928 – 2003

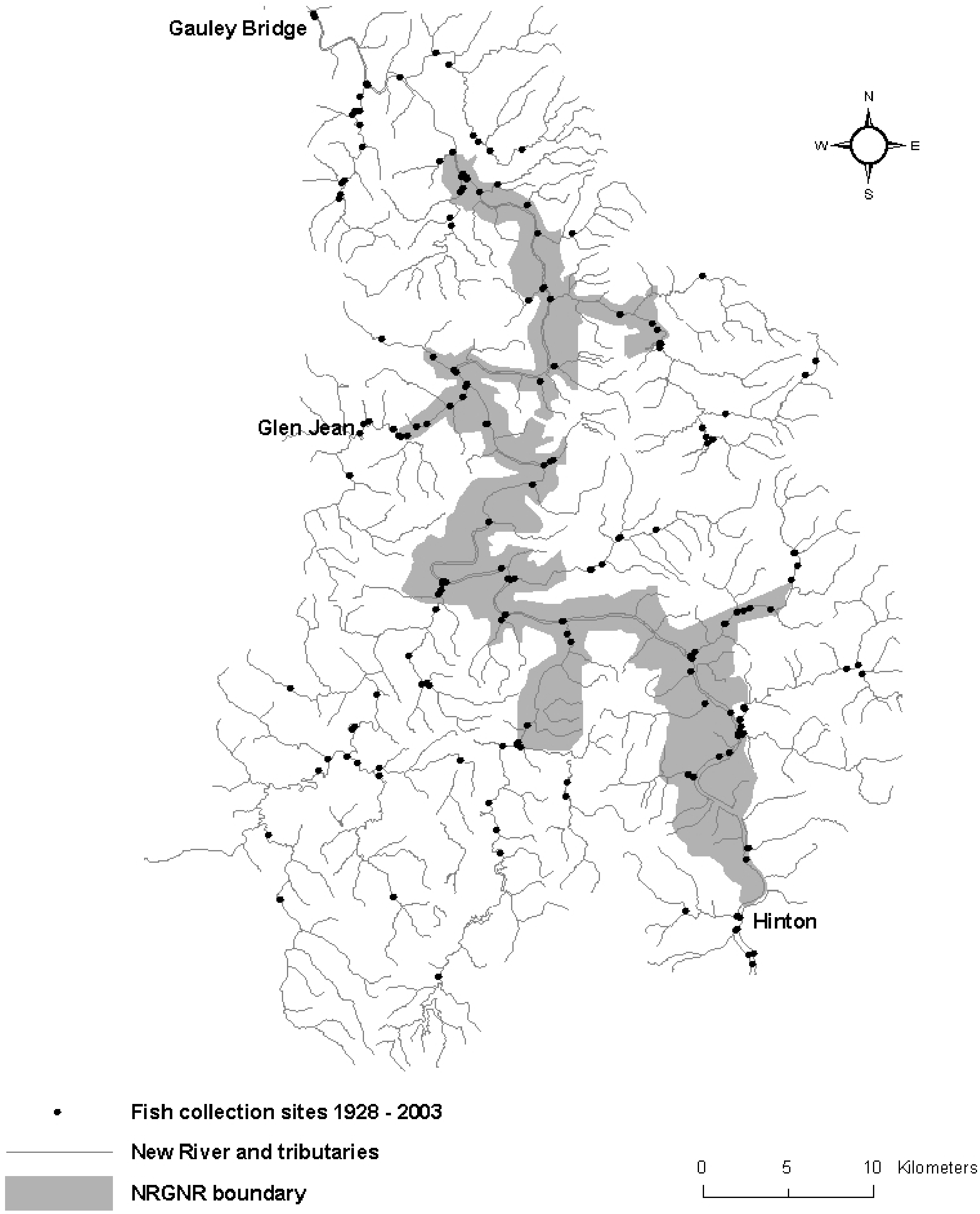

Figure 2. Sites of fish collections (1928 – 2003) within or near the New River Gorge National River. Location descriptions are in Table 1.

Dorosoma cepedianum (gizzard shad)

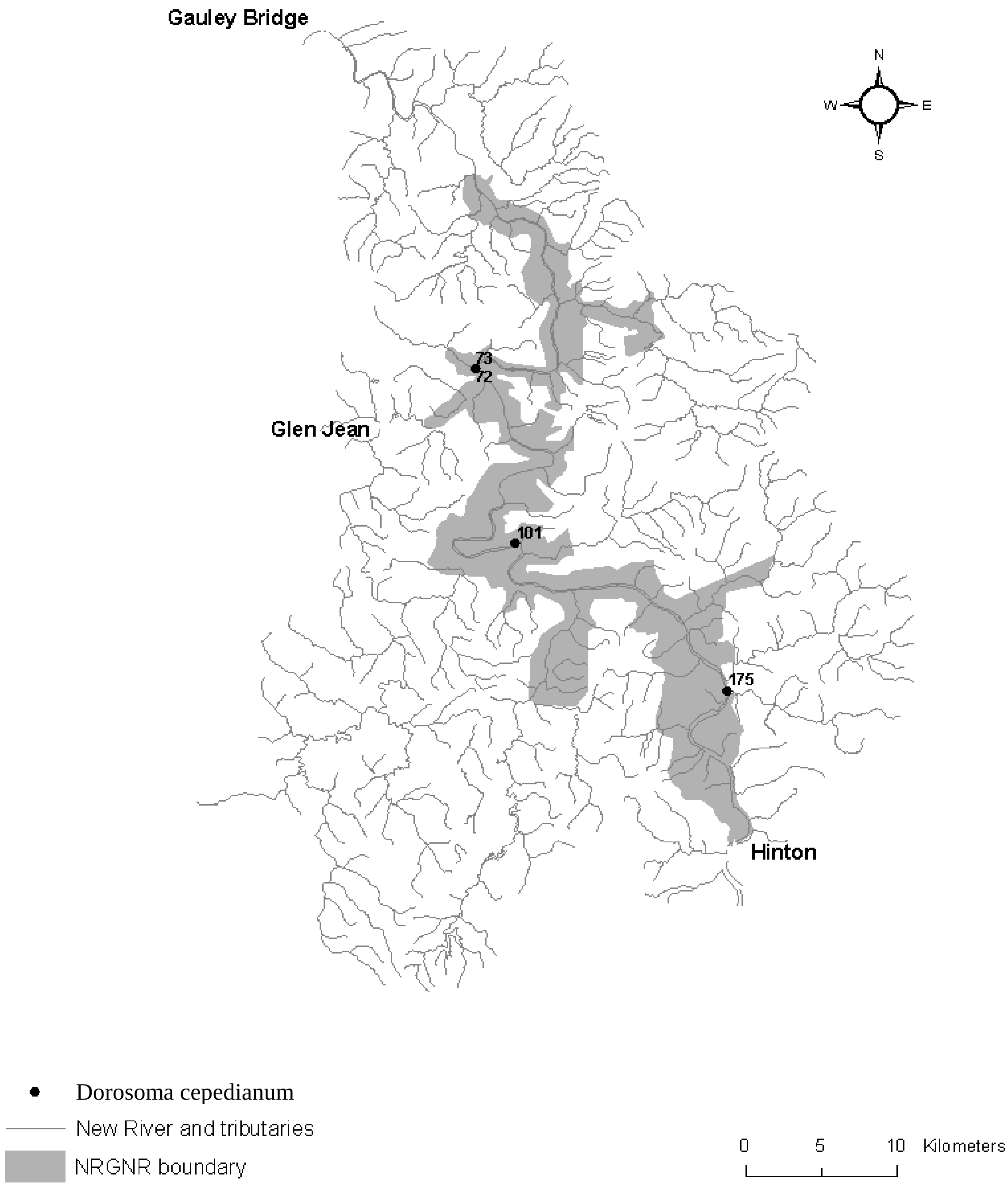

Figure 3. Collection sites for *Dorosoma cepedianum* (gizzard shad) within and near the New River Gorge National River.

*Esox masquinongy (*muskellunge)

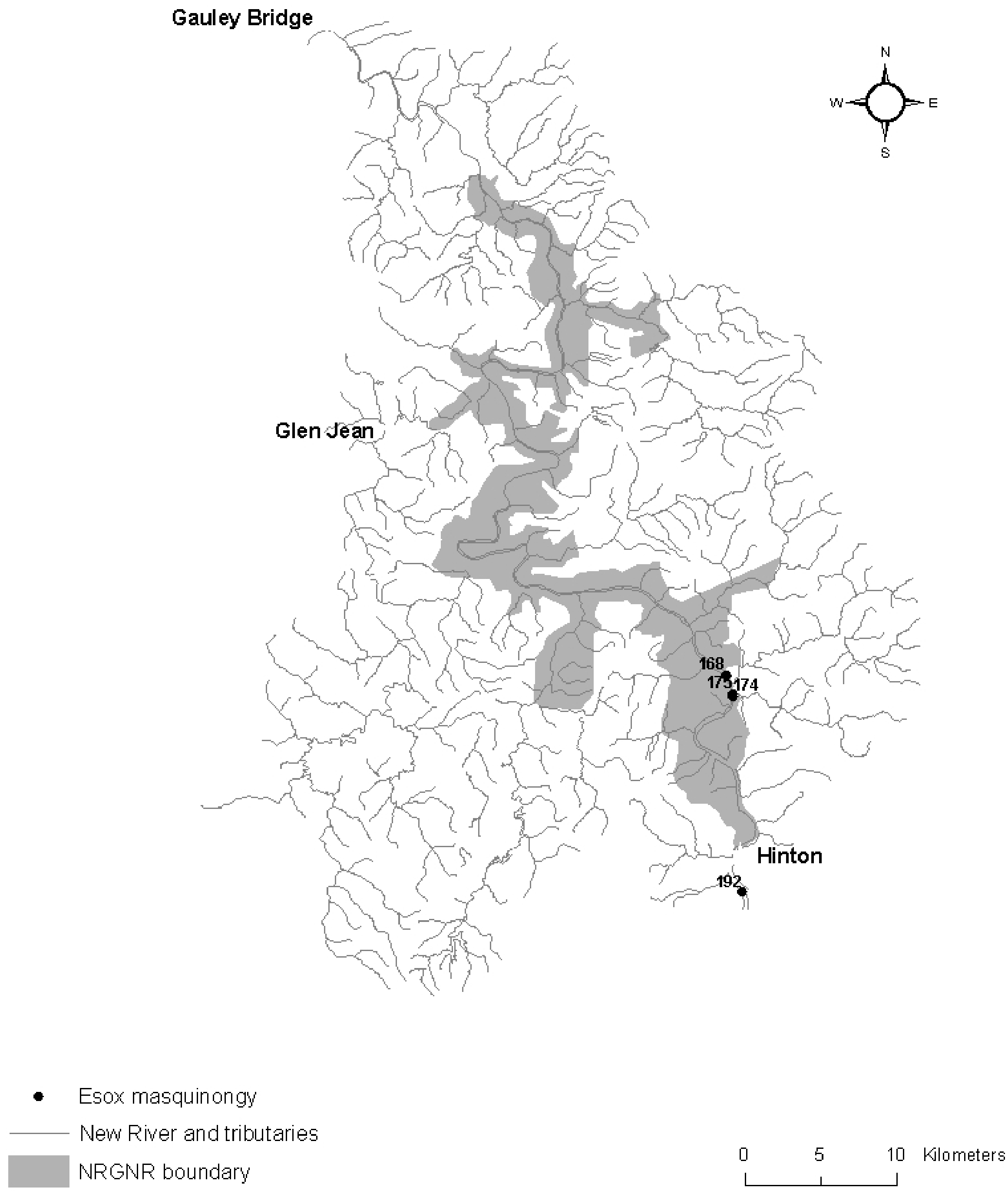

Figure 4. Collection sites for *Esox masquinongy* (muskellunge) within and near the New River Gorge National River.

*Campostoma anomalum (*central stoneroller*)*

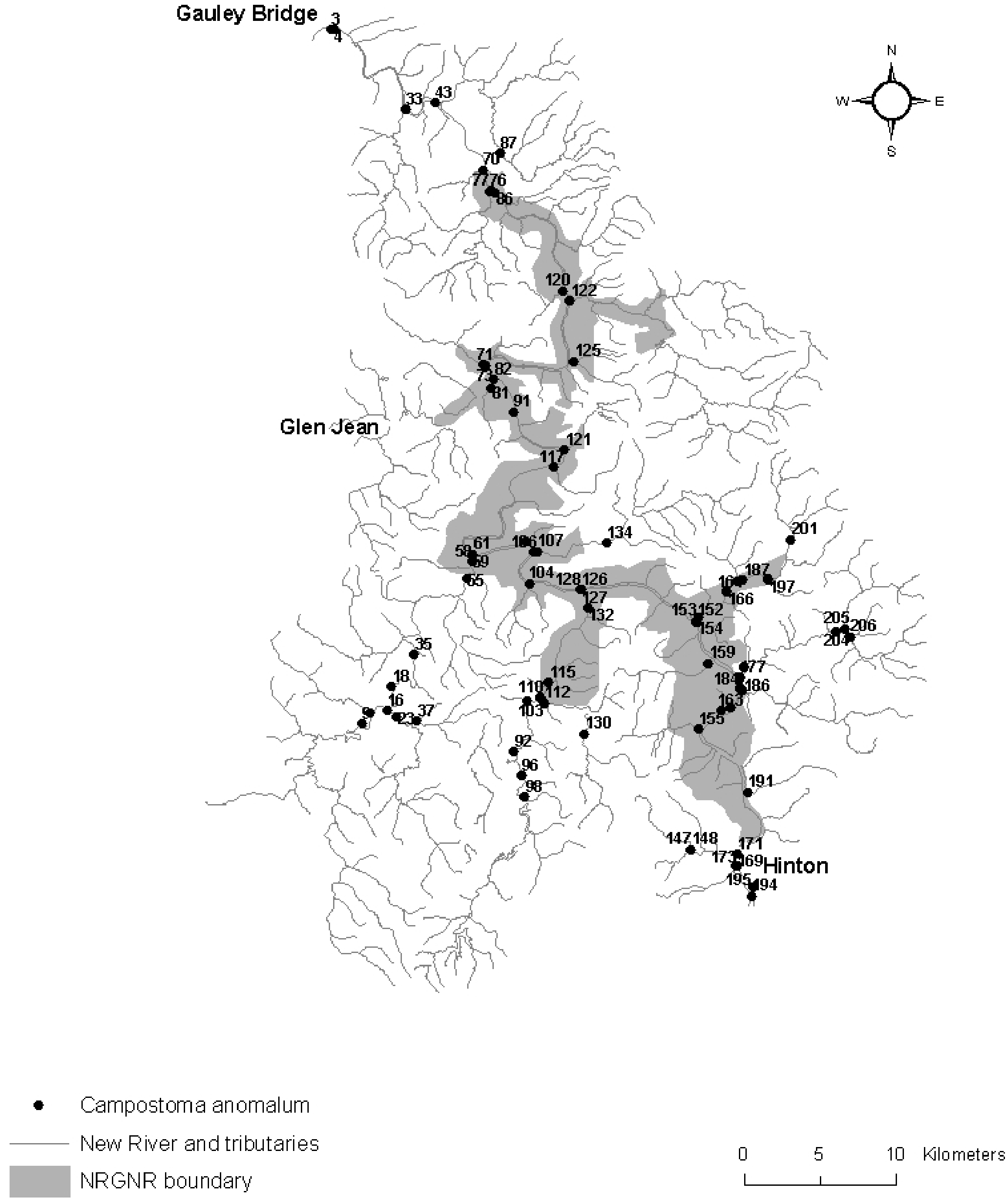

Figure 5. Collection sites for *Campostoma anomalum* (central stoneroller) within and near the New River Gorge National River.

Clinostomus funduloides (rosyside dace)

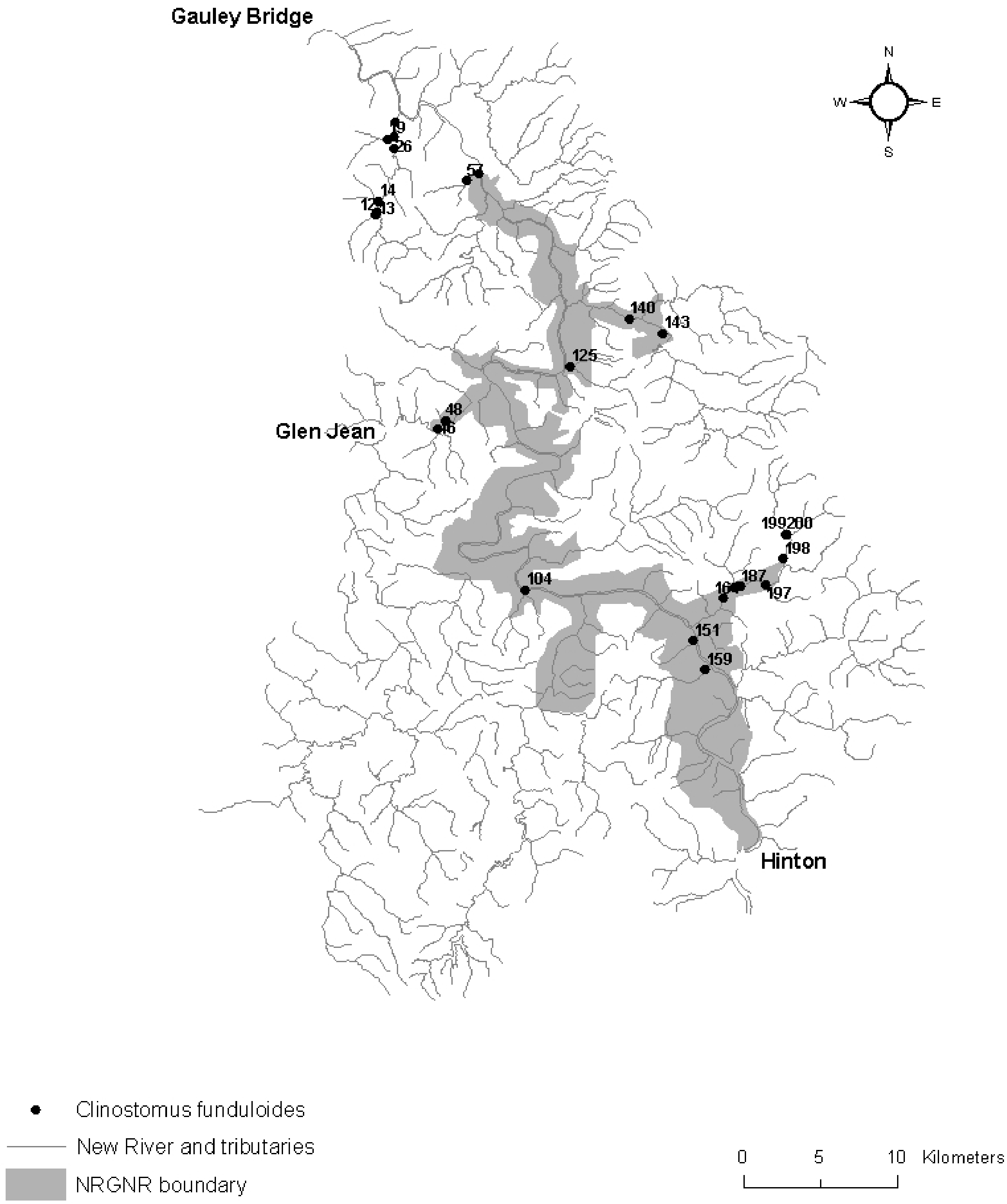

Figure 6. Collection sites for *Clinostomus funduloides* (rosyside dace) within and near the New River Gorge National River.

Cyprinella galactura (whitetail shiner)

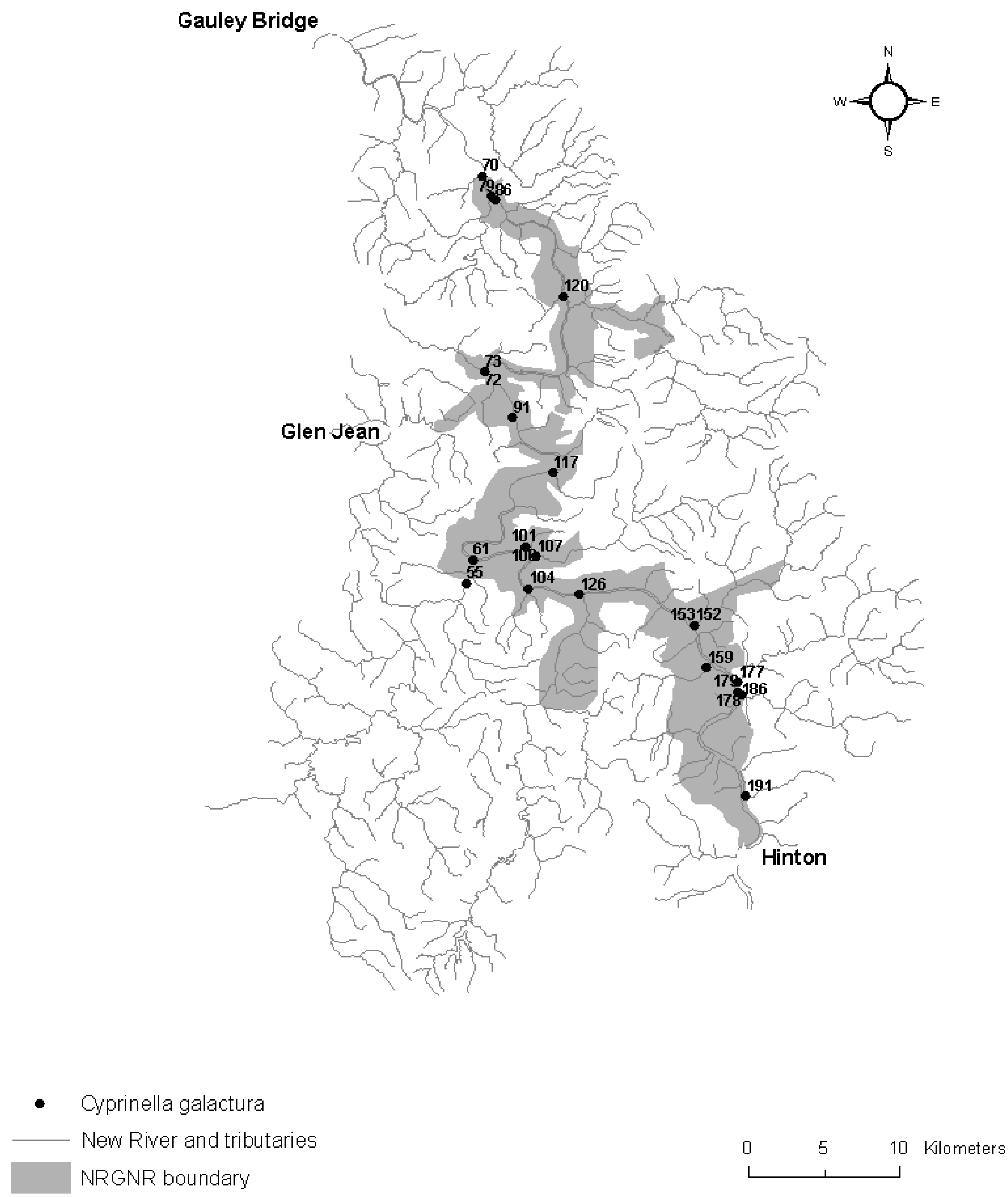

Figure 7. Collection sites for *Cyprinella galactura* (whitetail shiner) within and near the New River Gorge National River.

Cyprinella spiloptera (spotfin shiner)

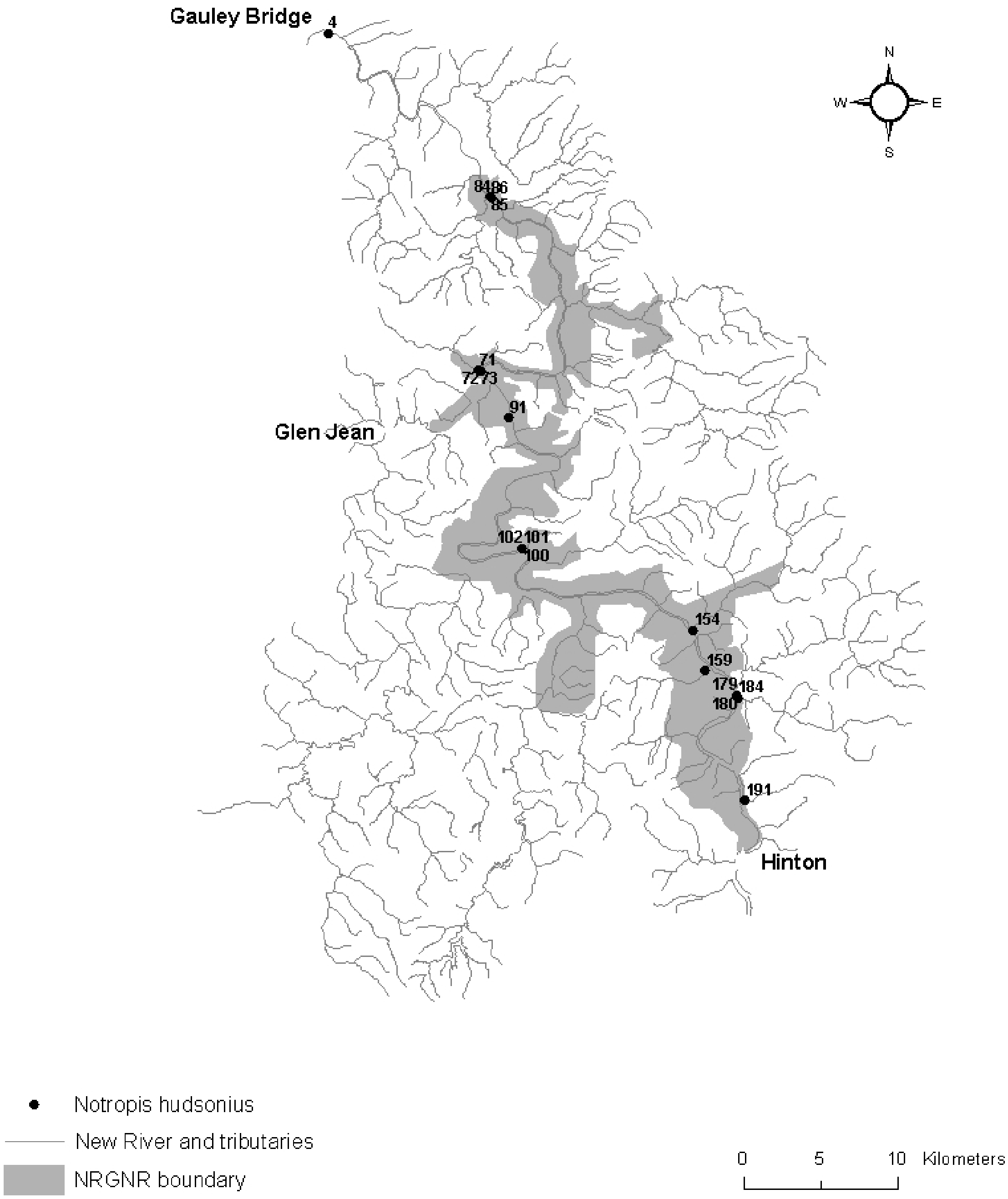

Figure 8. Collection sites for *Cyprinella spiloptera* (spotfin shiner) within and near the New River Gorge National River.

Cyprinus carpio (common carp)

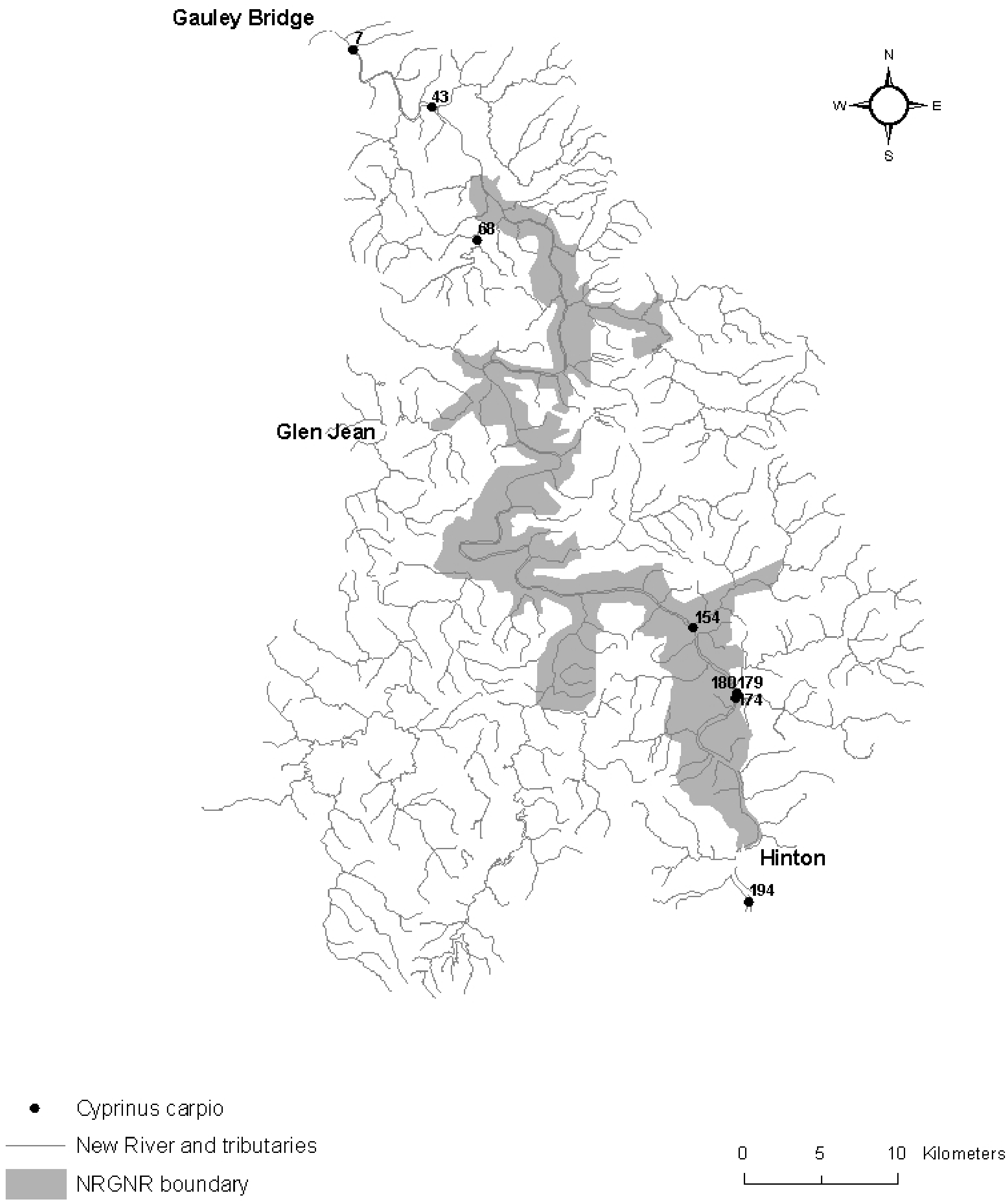

Figure 9. Collection sites for *Cyprinus carpio* (common carp) within and near the New River Gorge National River.

Ericymba buccata (silverjaw minnow)

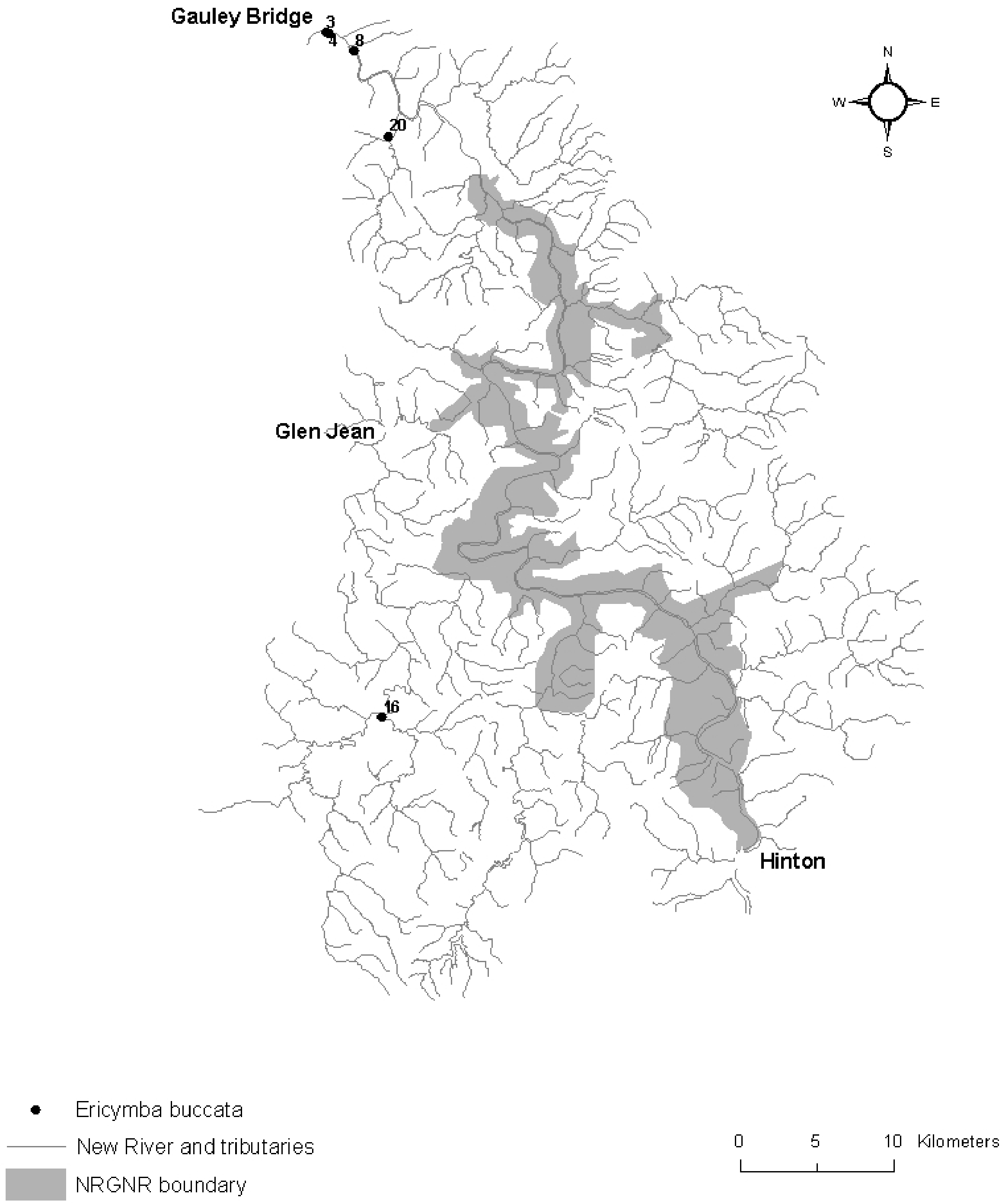

Figure 10. Collection sites for *Ericymba buccata* (silverjaw minnow) within and near the New River Gorge National River.

Erimystax dissimilis (streamline chub)

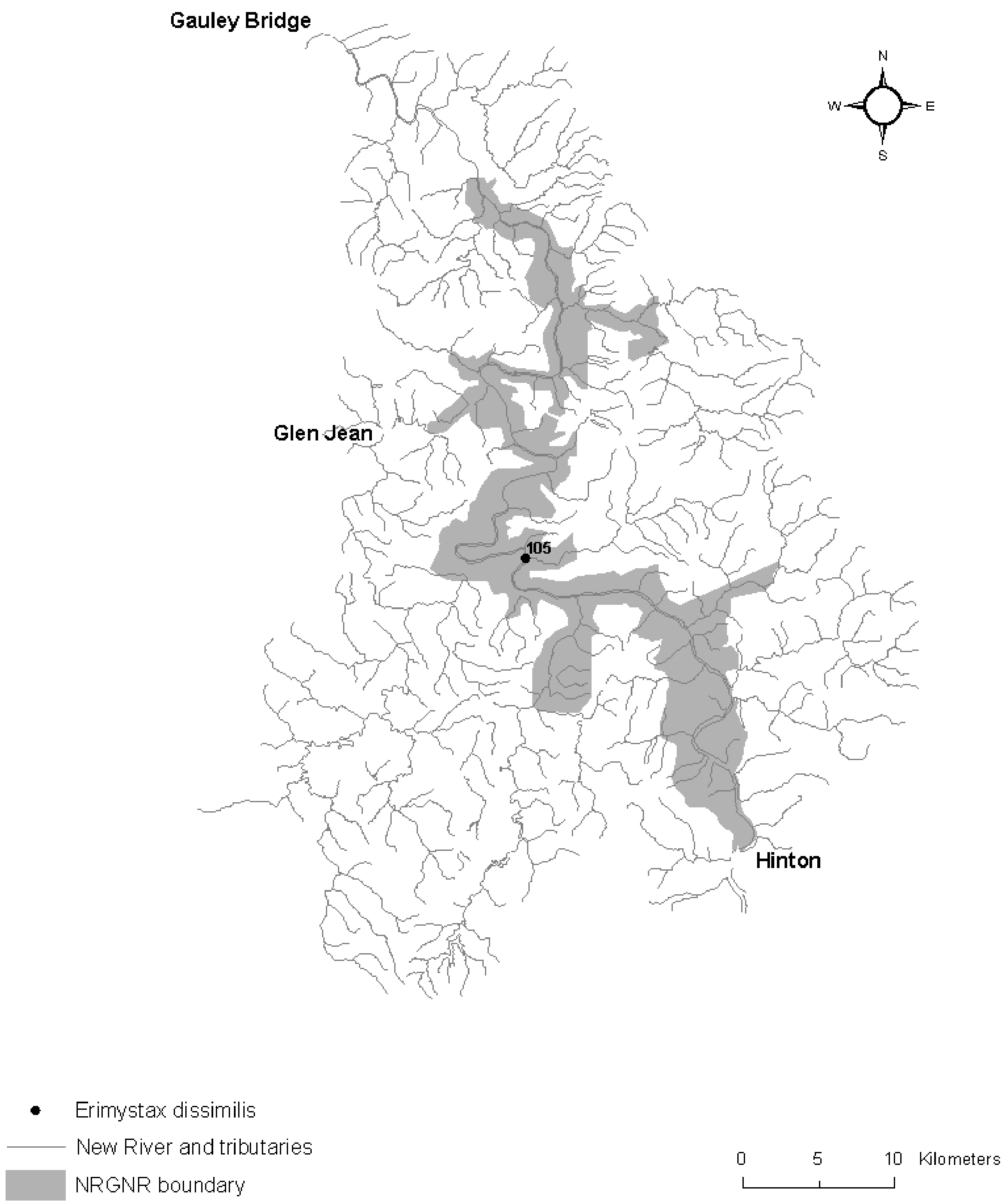

Figure 11. Collection sites for *Erimystax dissimilis* (streamline chub) within and near the New River Gorge National River.

Exoglossum laurae (tonguetied minnow)

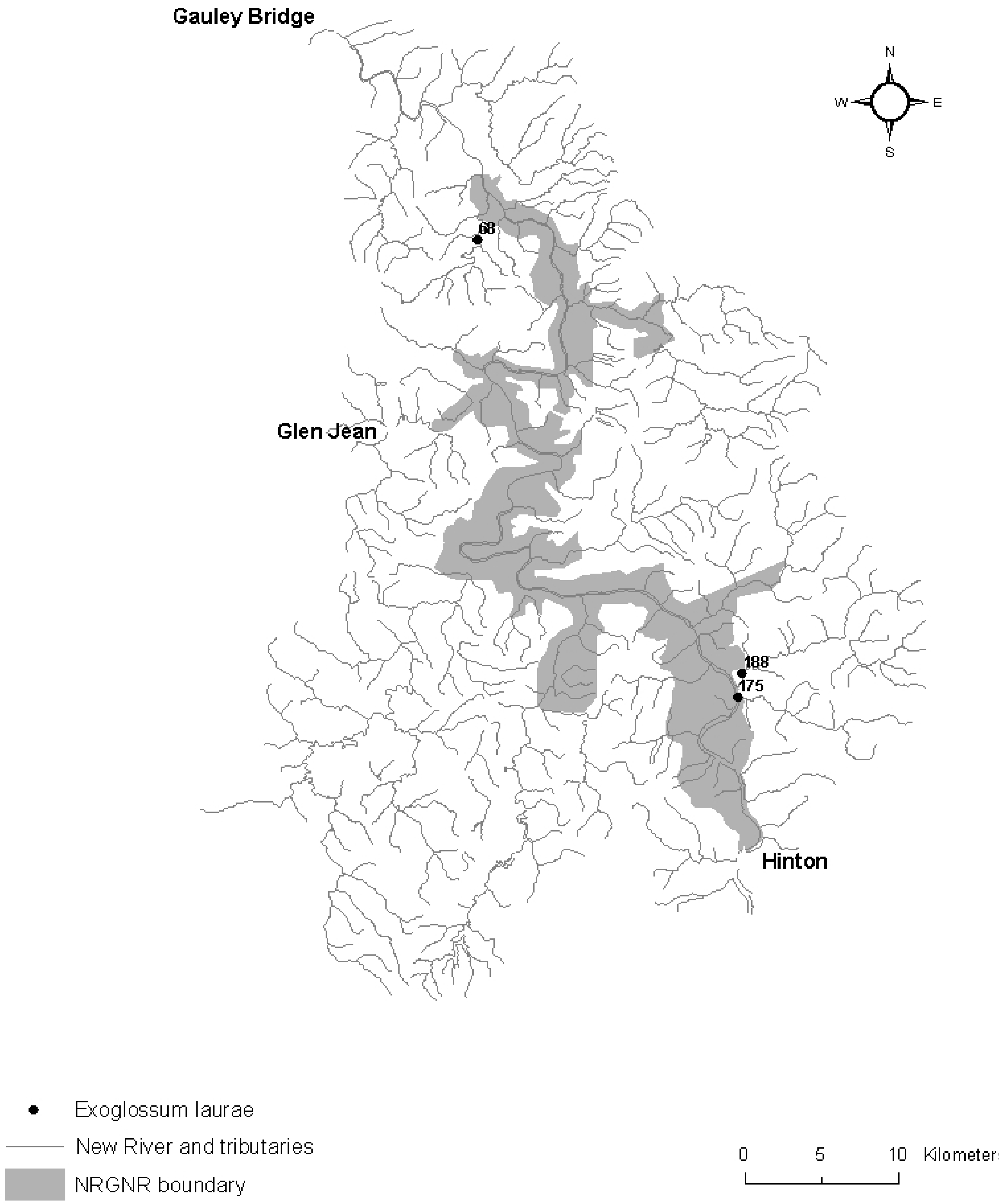

Figure 12. Collection sites for *Exoglossum laurae* (tonguetied minnow) within and near the New River Gorge National River.

Luxilus albeolus (white shiner)

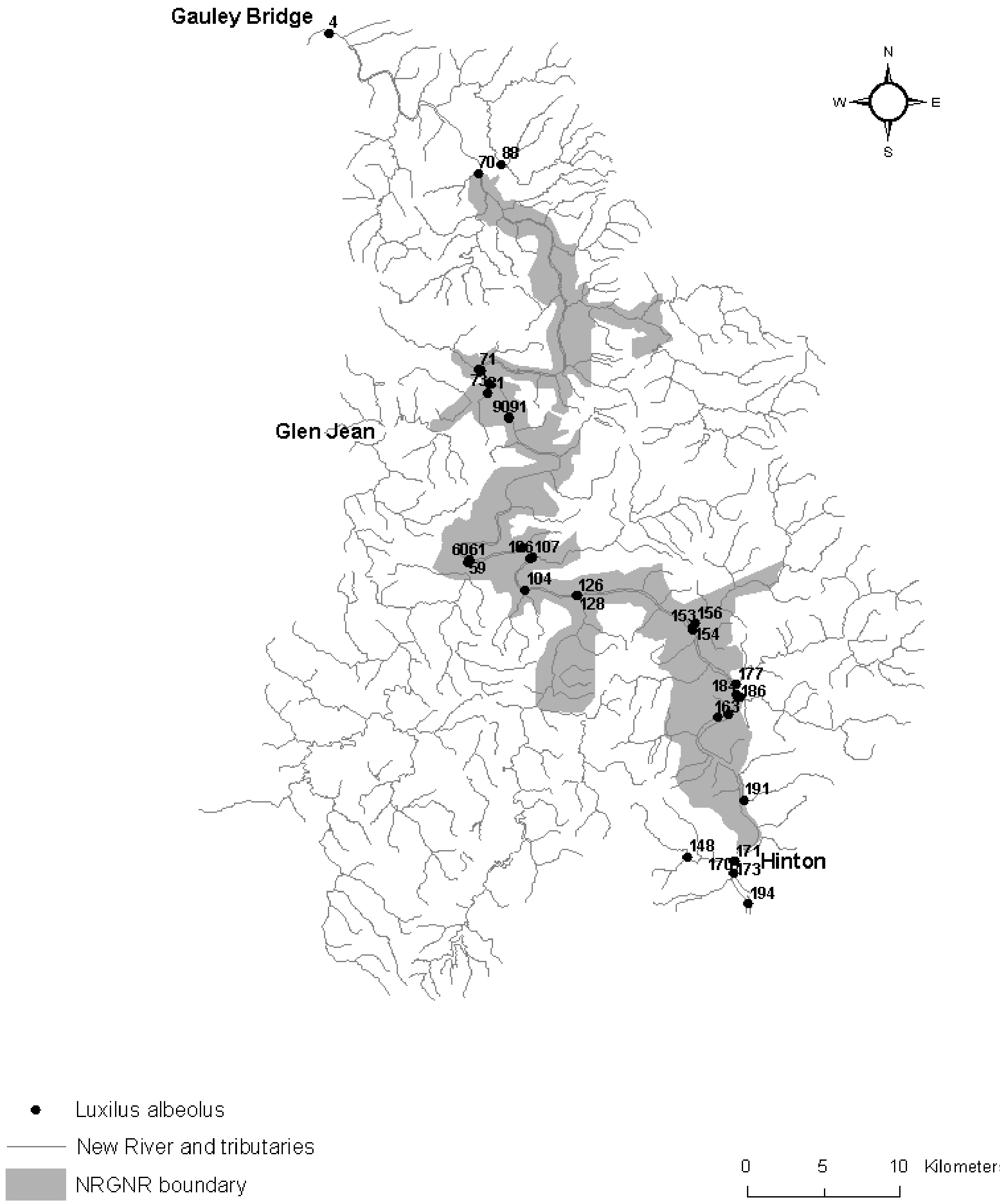

Figure 13. Collection sites for *Luxilus albeolus* (white shiner) within and near the New River Gorge National River.

Luxilus chrysocephalus (striped shiner)

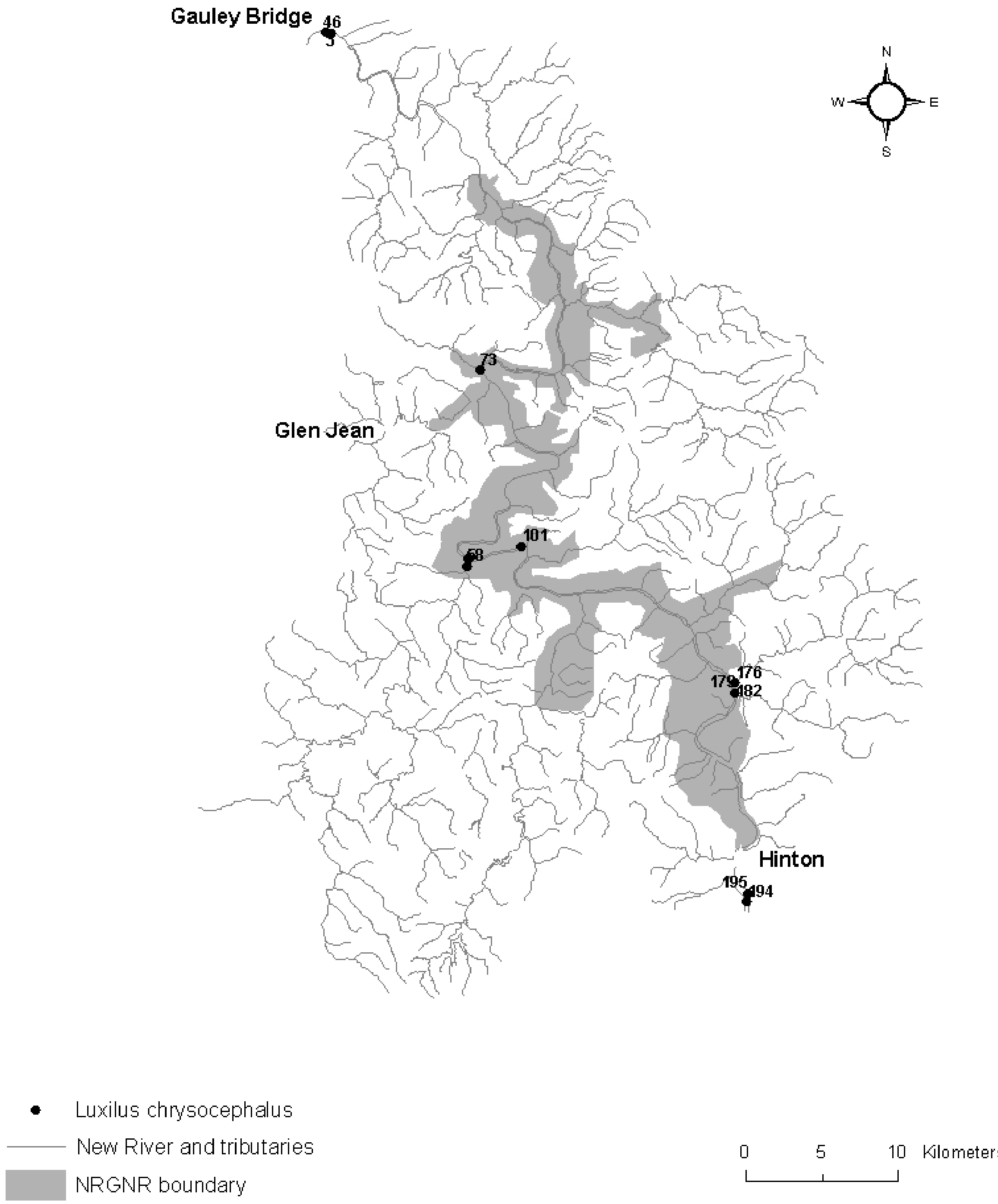

Figure 14. Collection sites for *Luxilus chrysocphalus* (striped shiner) within and near the New River Gorge National River.

Nocomis platyrhynchus (bigmouth chub)

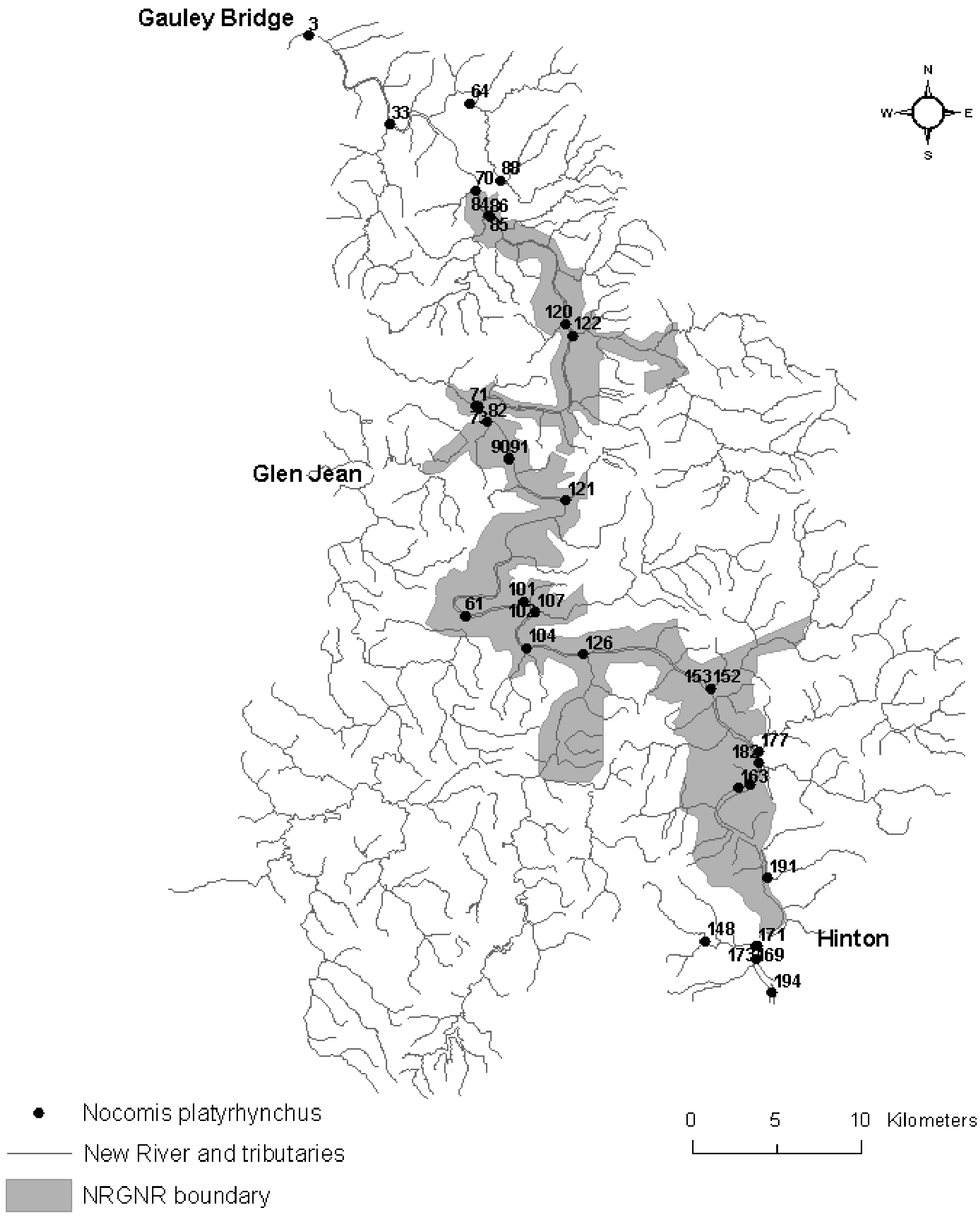

Figure 15. Collection sites for *Nocomis platyrhynchus* (bigmouth chub) within and near the New River Gorge National River.

Notemigonus crysoleucas (golden shiner)

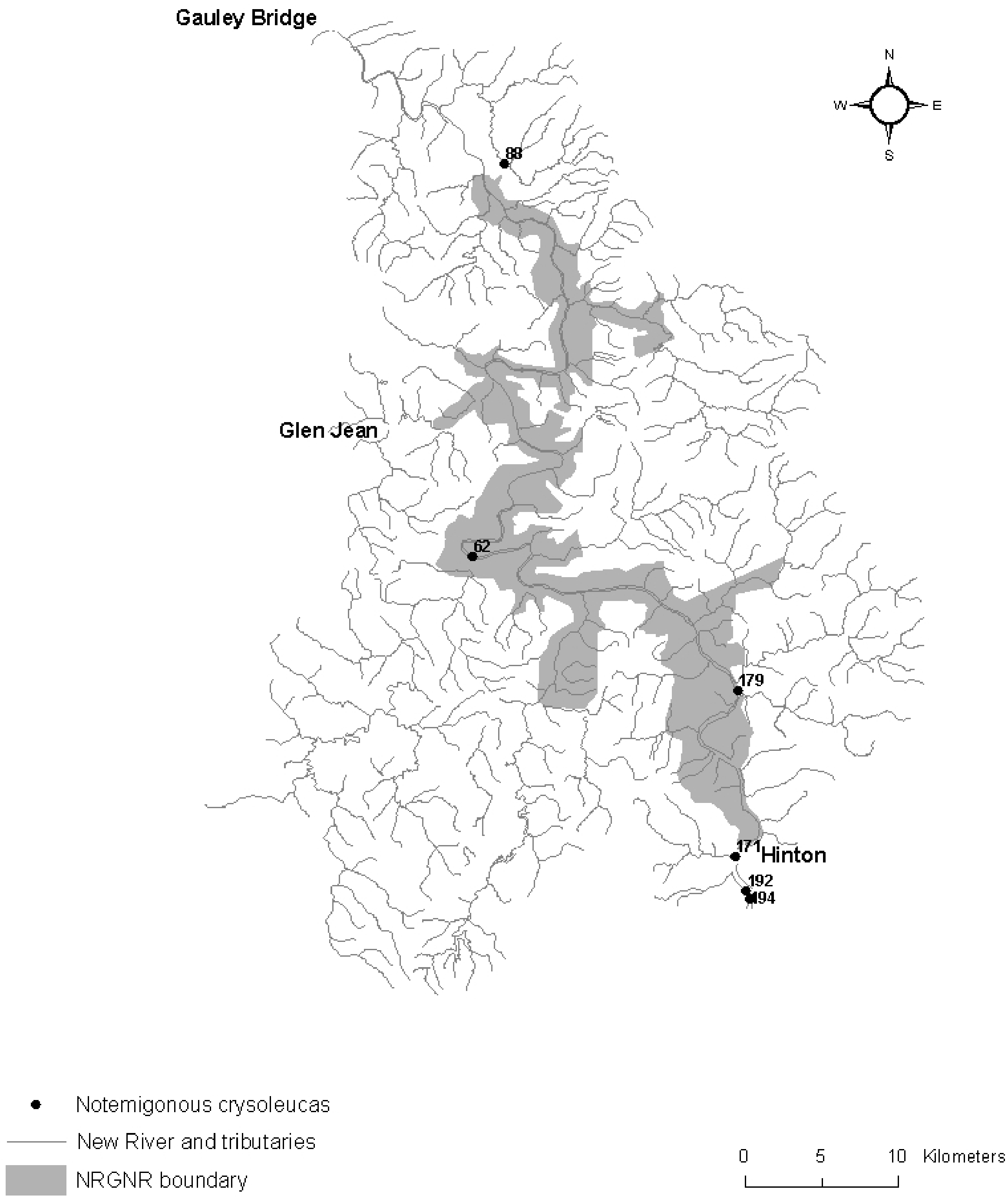

Figure 16. Collection sites for *Notemigonus crysoleucas* (golden shiner) within and near the New River Gorge National River.

Notropis hudsonius (spottail shiner)

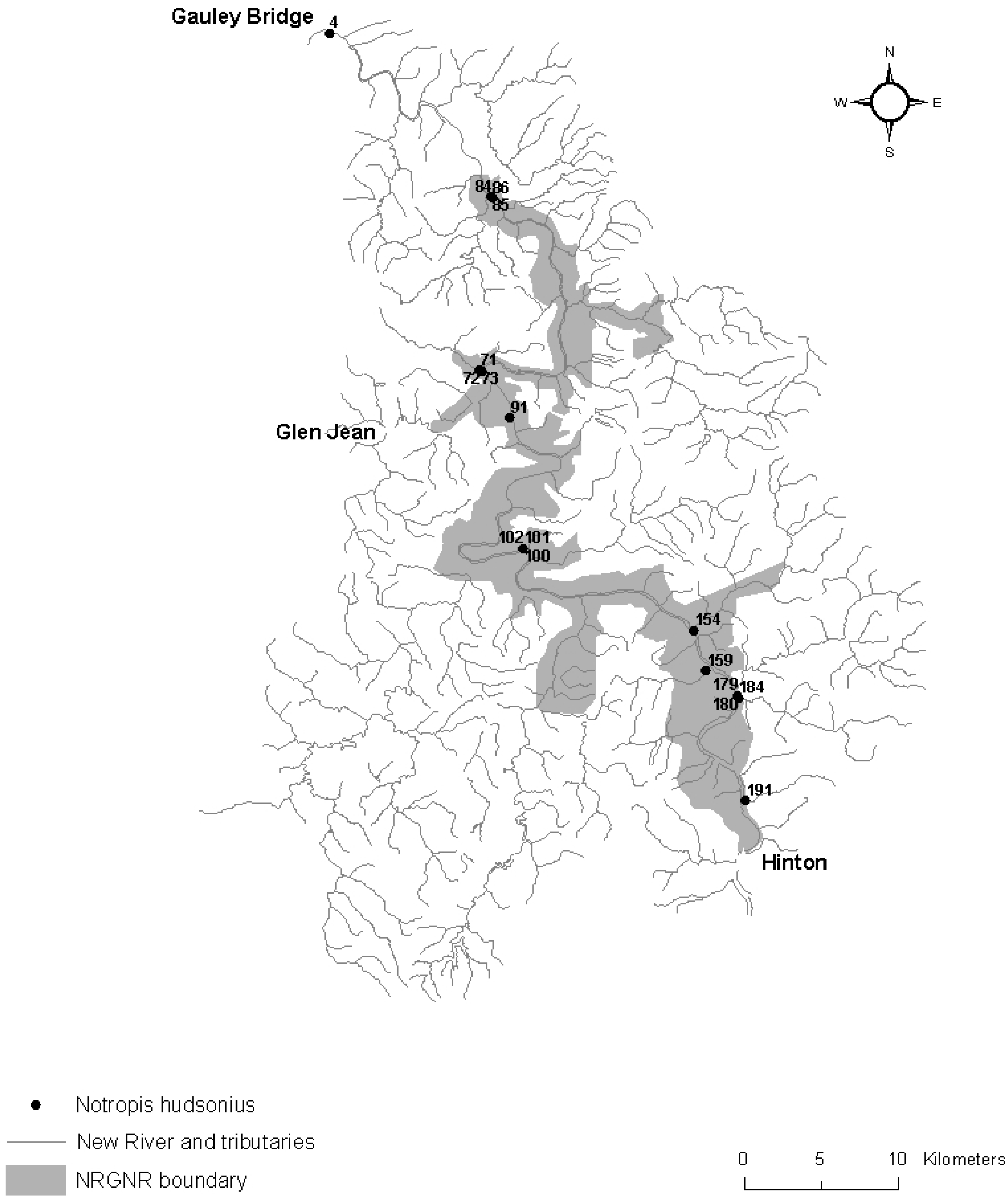

Figure 17. Collection sites for *Notropis hudsonius* (spottail shiner) within and near the New River Gorge National River.

Notropis photogenis (silver shiner)

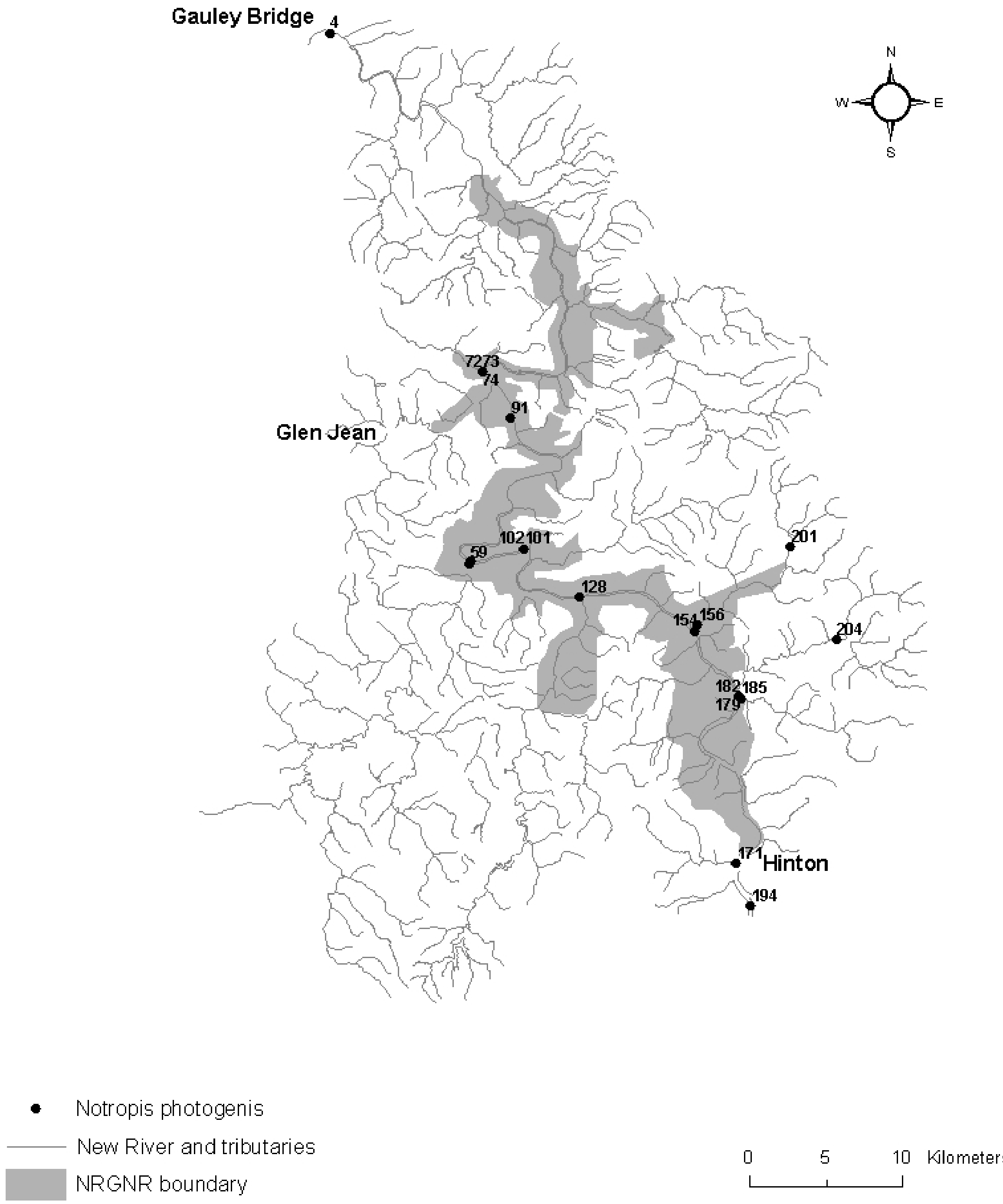

Figure 18. Collection sites for *Notropis photogenis* (silver shiner) within and near the New River Gorge National River.

***Notropis rubellus* (rosyface shiner)**

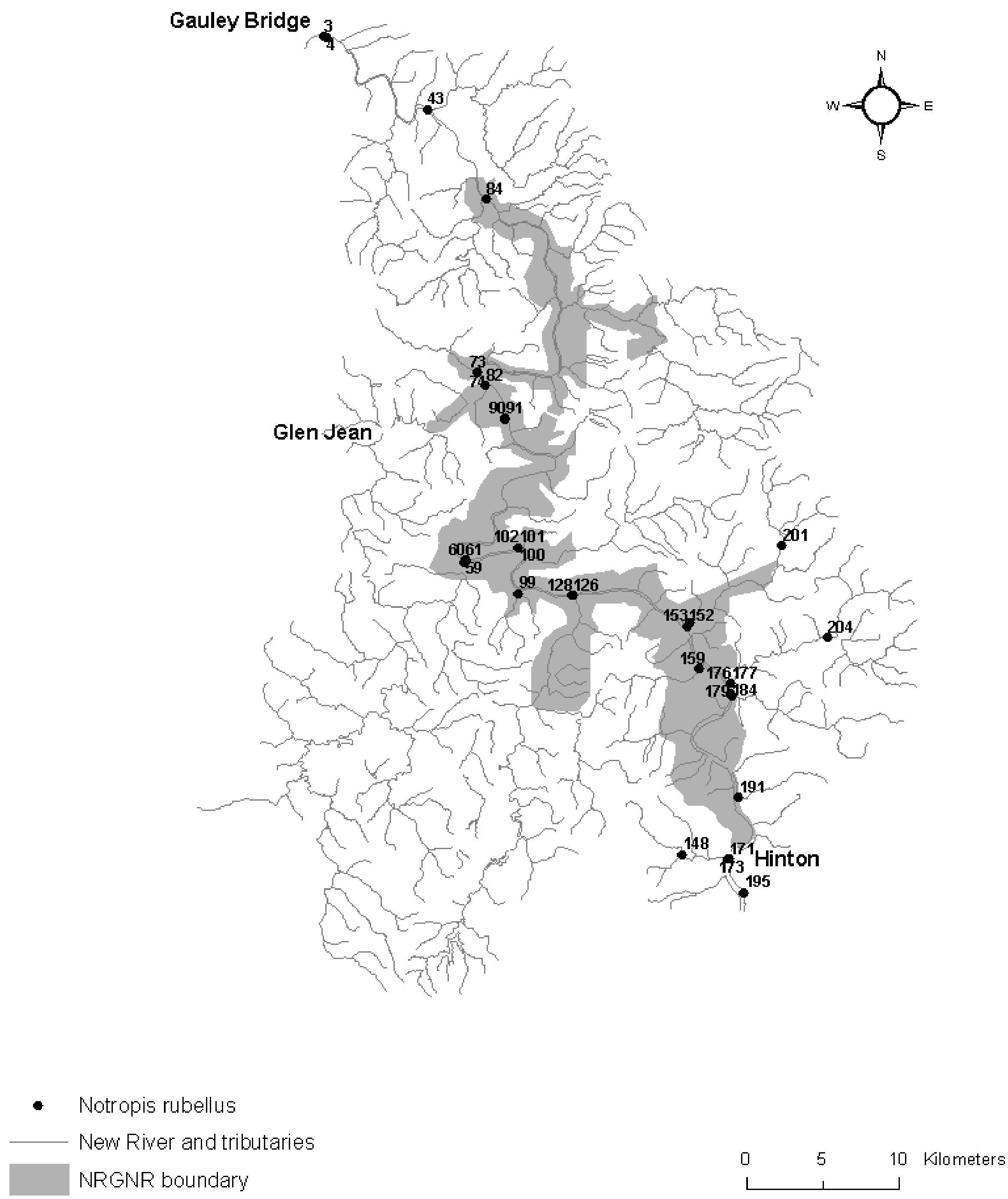

Figure 19. Collection sites for *Notropis rubellus* (rosyface shiner) within and near the New River Gorge National River.

Notropis scabriceps (New River shiner)

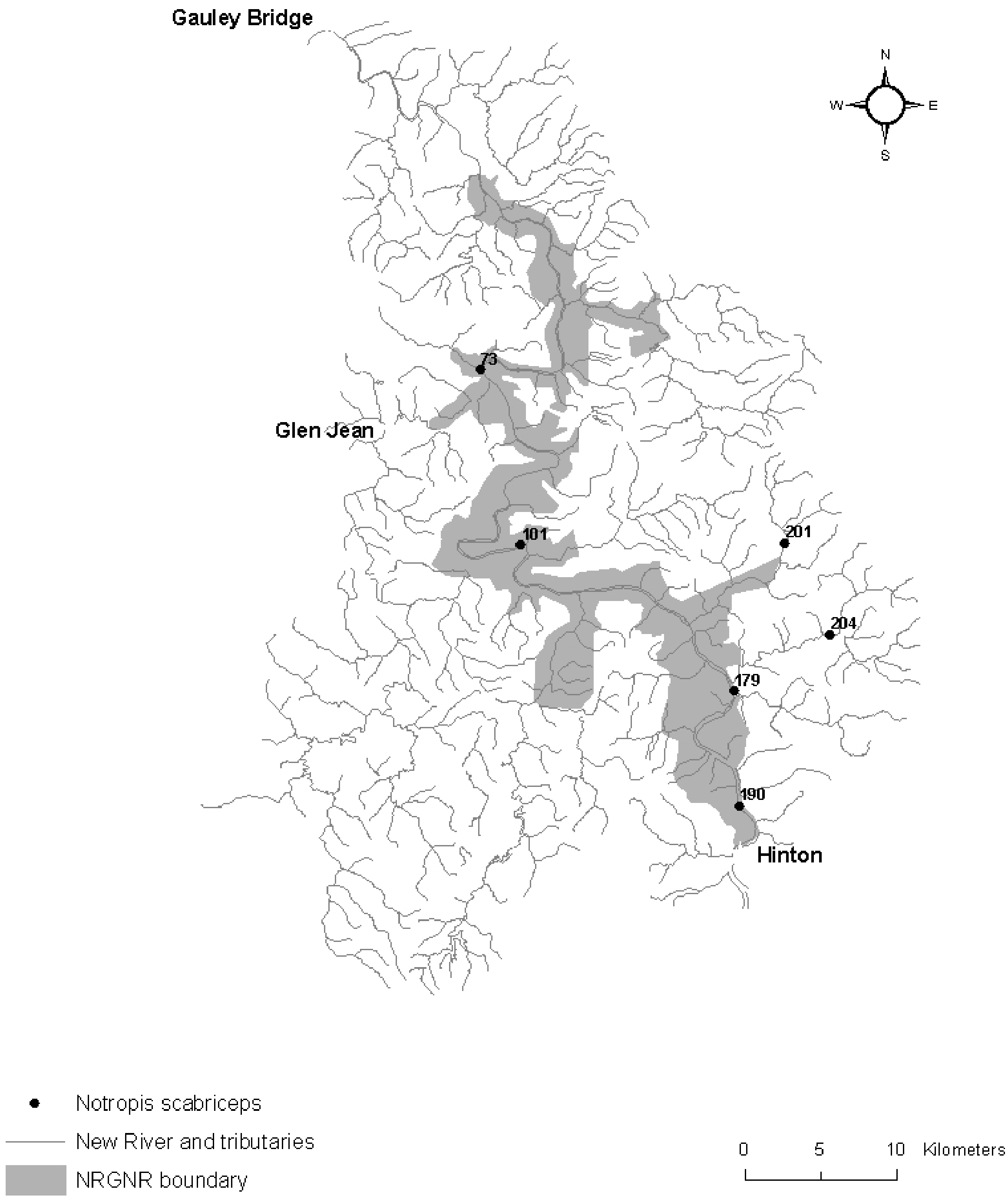

Figure 20. Collection sites for *Notropis scabriceps* (New River shiner) within and near the New River Gorge National River.

Notropis stramineus (sand shiner)

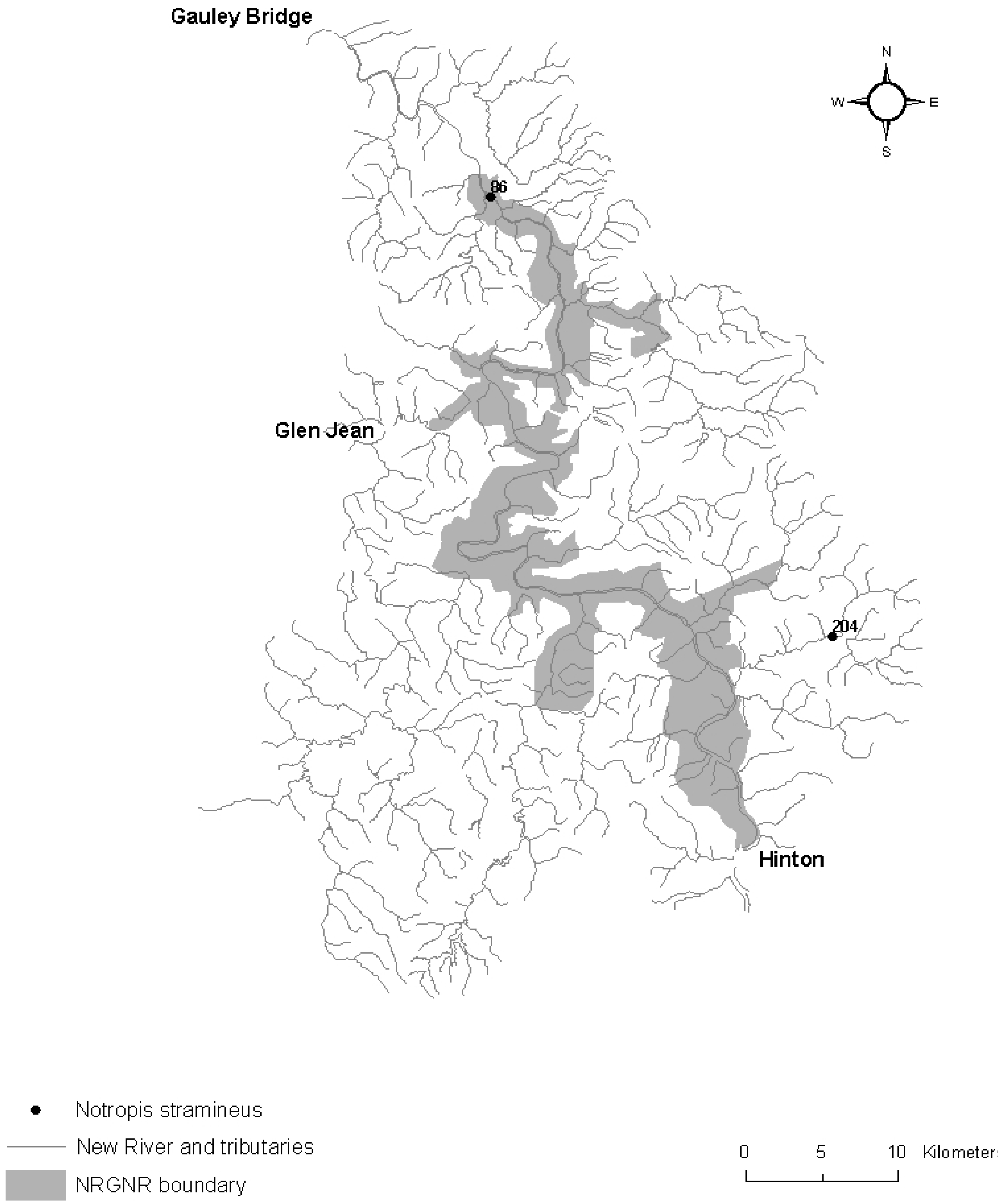

Figure 21. Collection sites for *Notropis stramineus* (sand shiner) within and near the New River Gorge National River.

Notropis telescopus (telescope shiner)

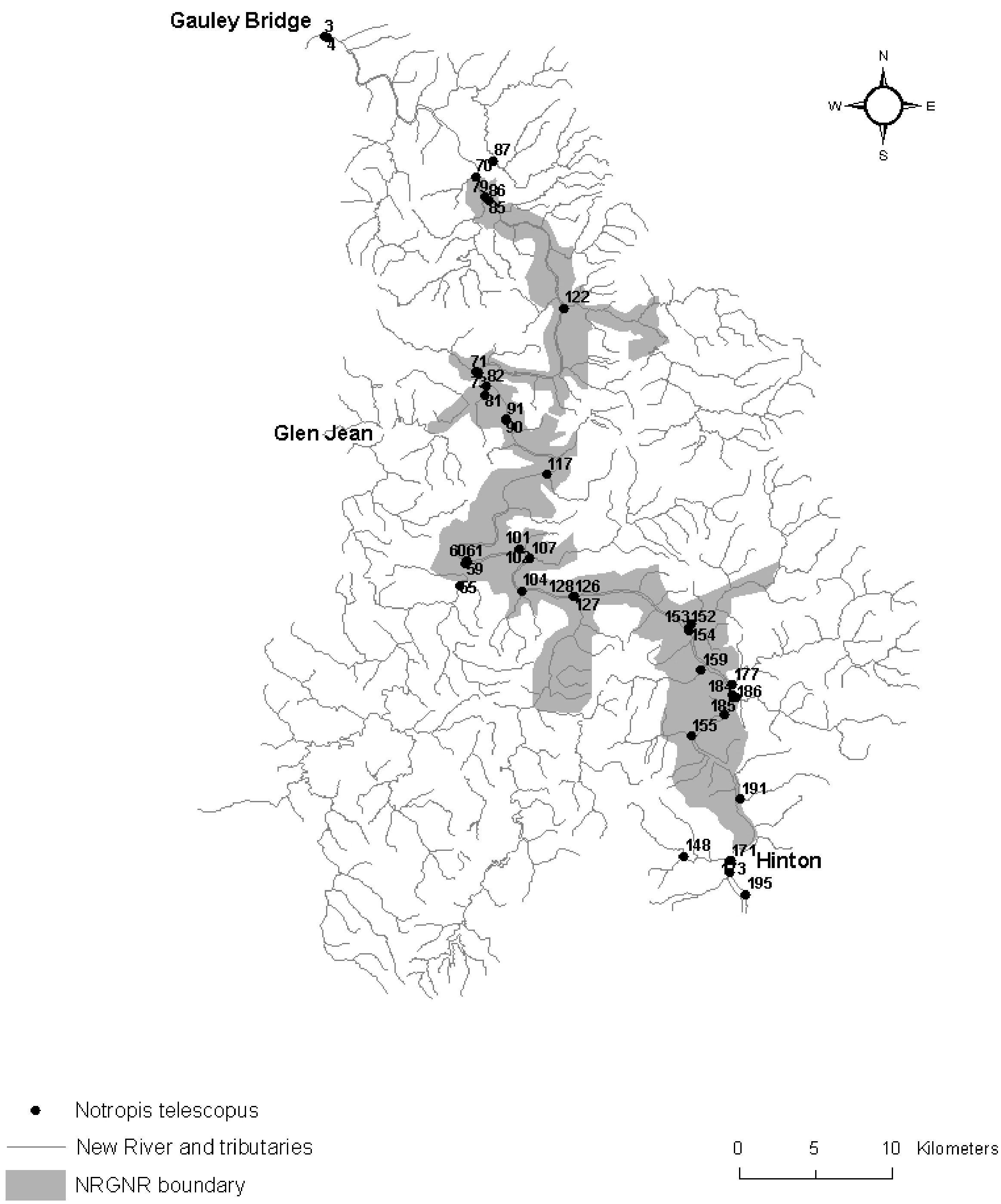

Figure 22. Collection sites for *Notropis telescopus* (telescope shiner) within and near the New River Gorge National River.

Notropis volucellus (mimic shiner)

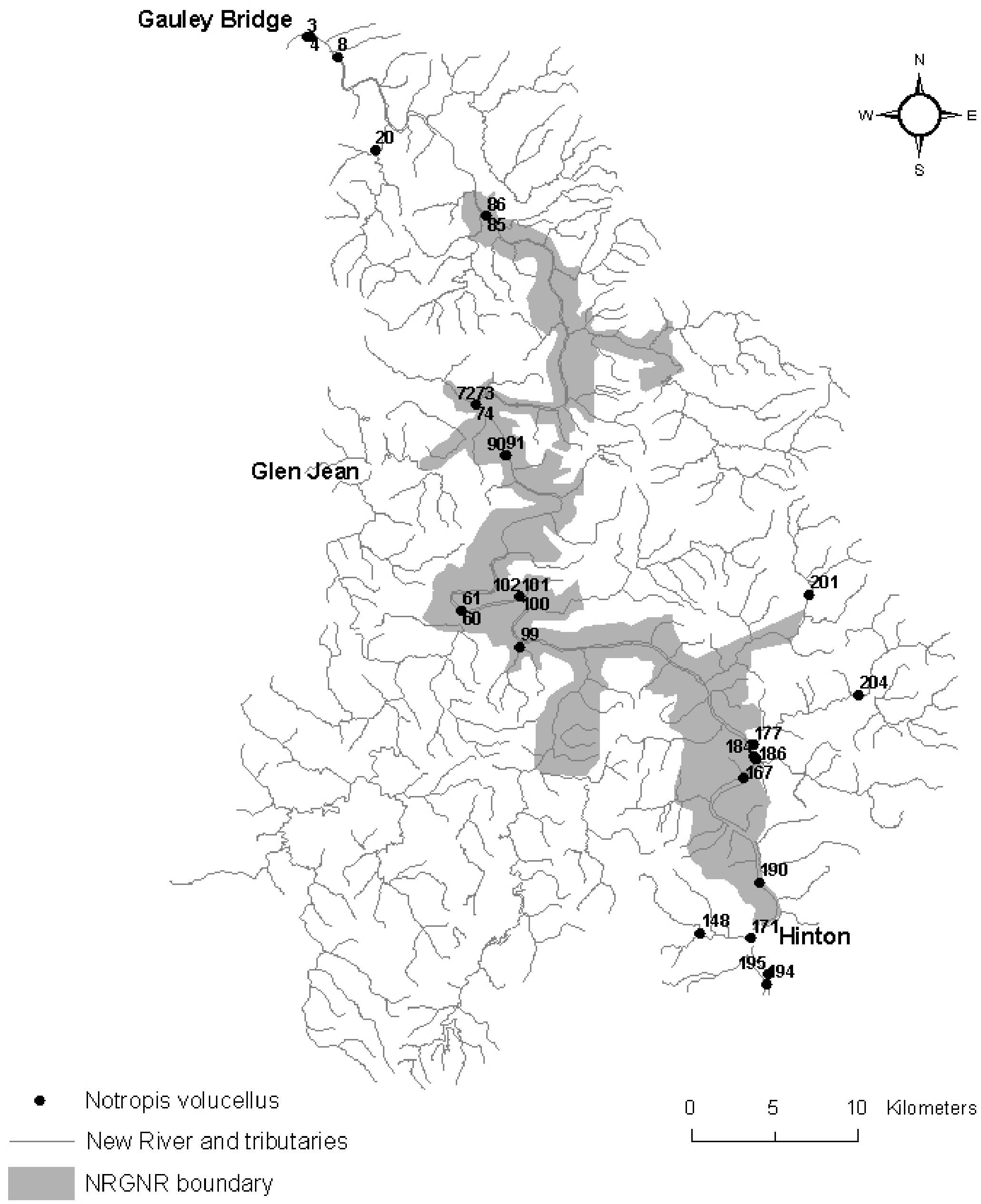

Figure 23. Collection sites for *Notropis volucellus* (mimic shiner) within and near the New River Gorge National River.

Phoxinus oreas (mountain redbelly dace)

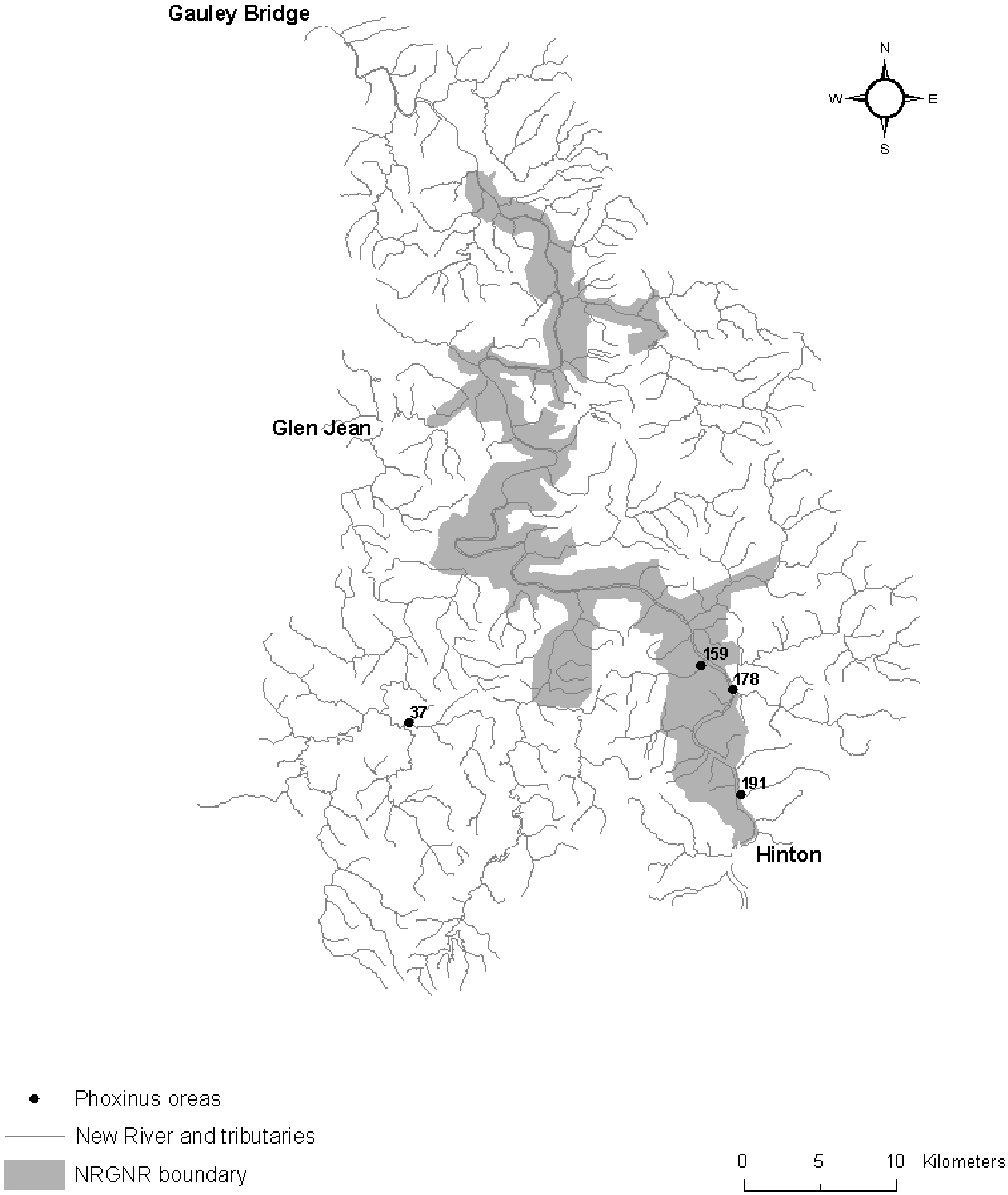

Figure 24. Collection sites for *Phoxinus oreas* (mountain redbelly dace) within and near the New River Gorge National River.

Pimephales notatus (bluntnose minnow)

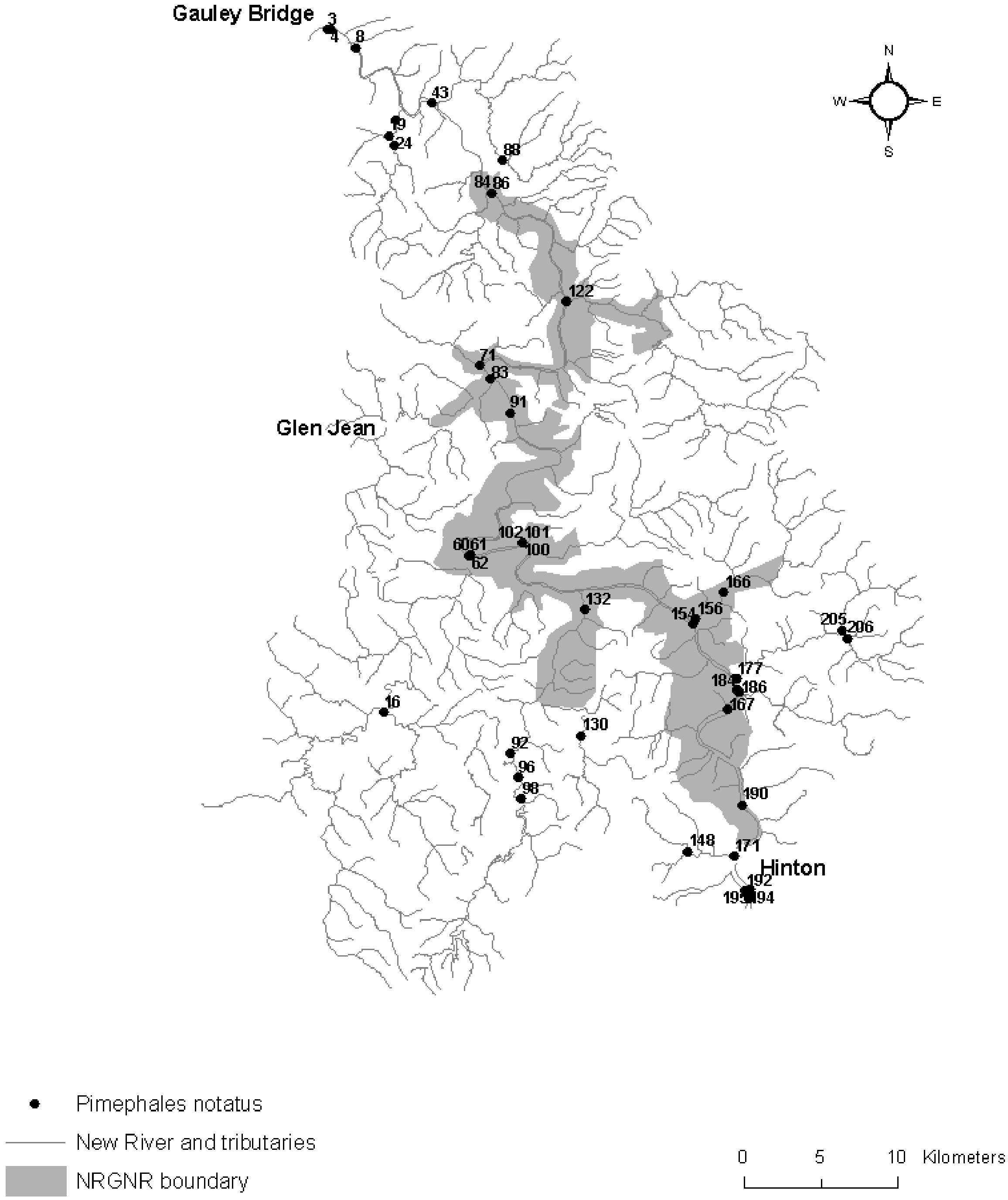

Figure 25. Collection sites for *Pimephales notatus* (bluntnose minnow) within and near the New River Gorge National River.

Pimephales promelas (fathead minnow)

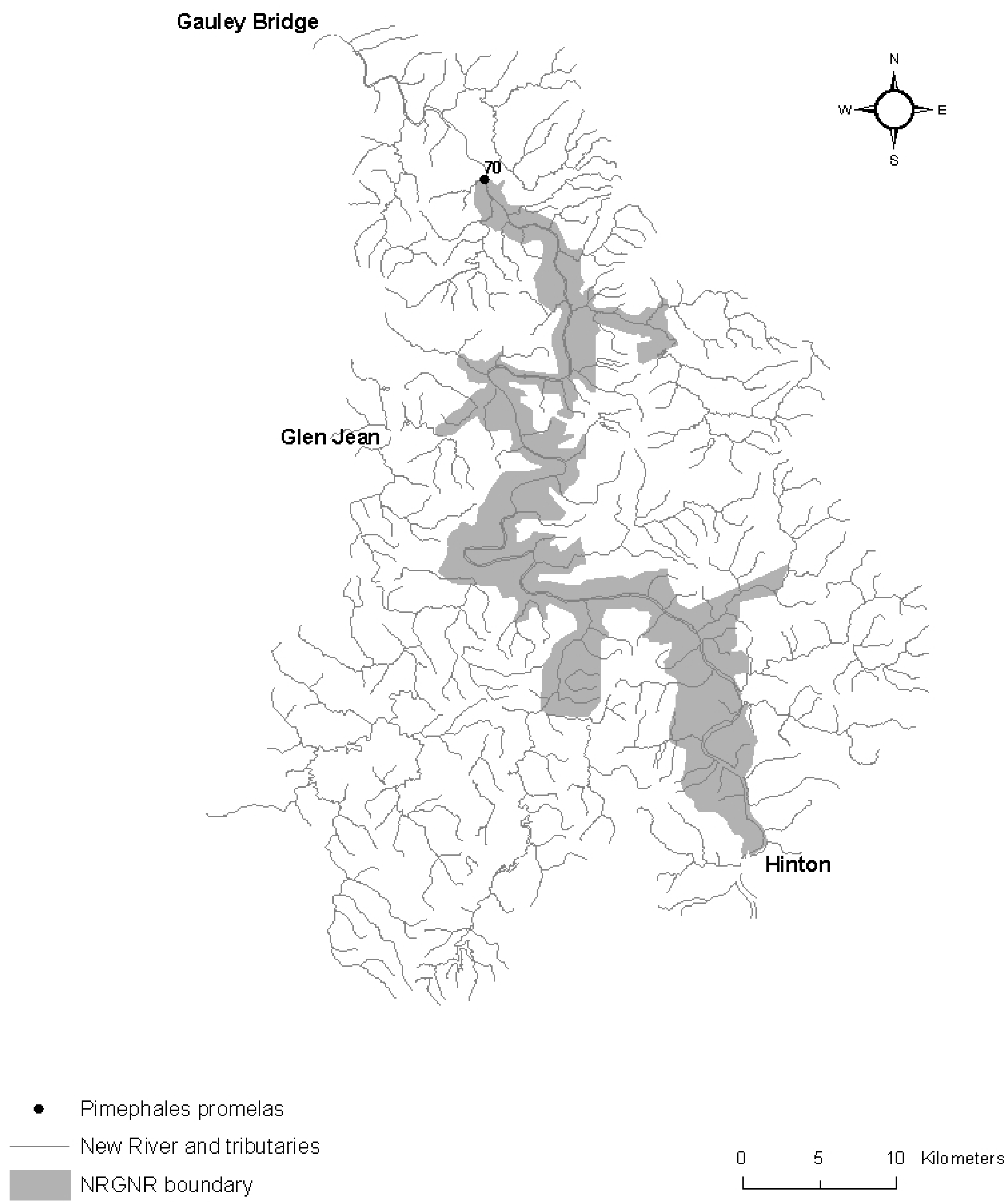

Figure 26. Collection site for *Pimephales promelas* (fathead minnow) within the New River Gorge National River.

Rhinichthys atratulus (blacknose dace)

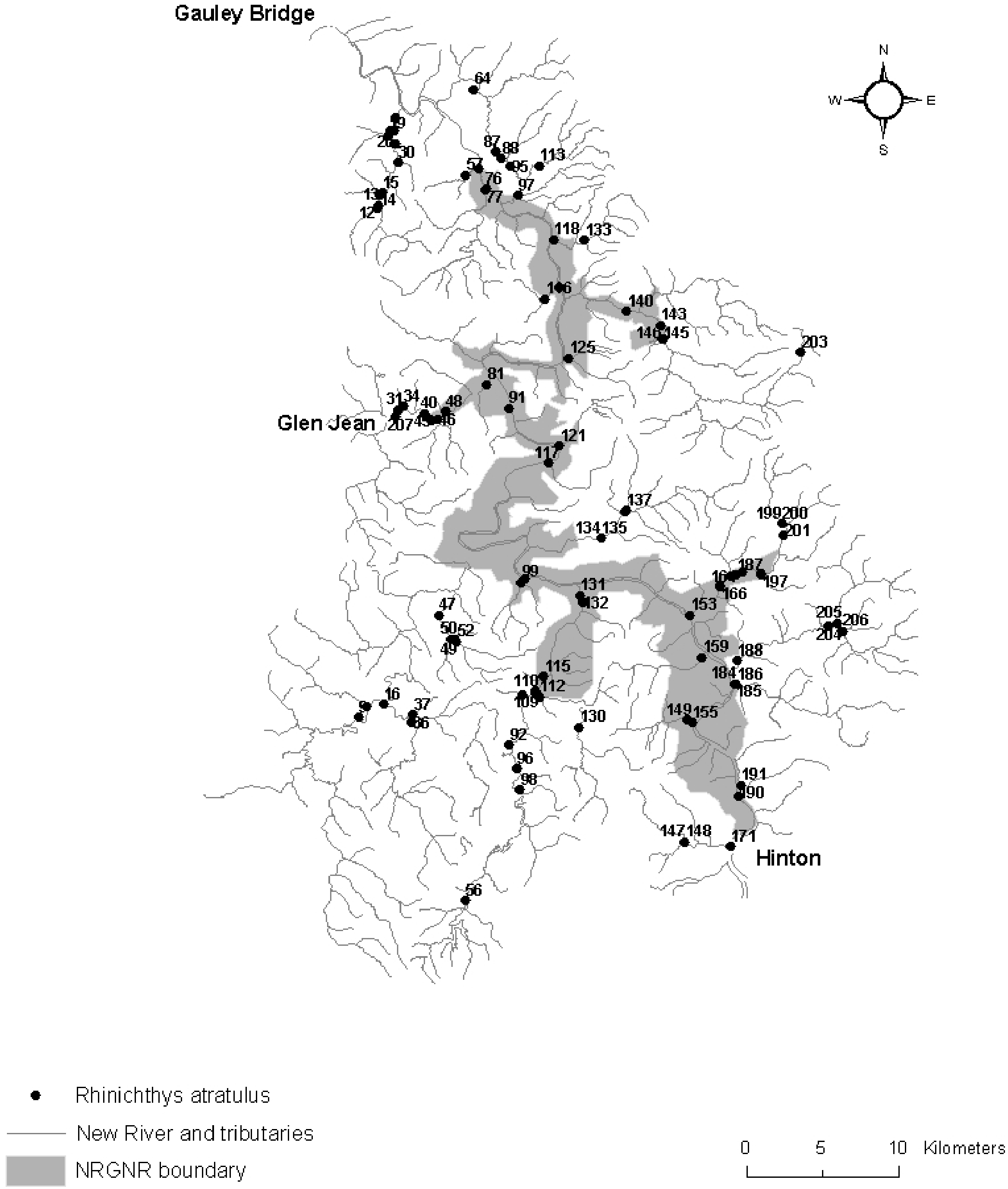

Figure 27. Collection sites for *Rhinichthys atratulus* (blacknose dace) within and near the New River Gorge National River.

Rhinichthys cataractae (longnose dace)

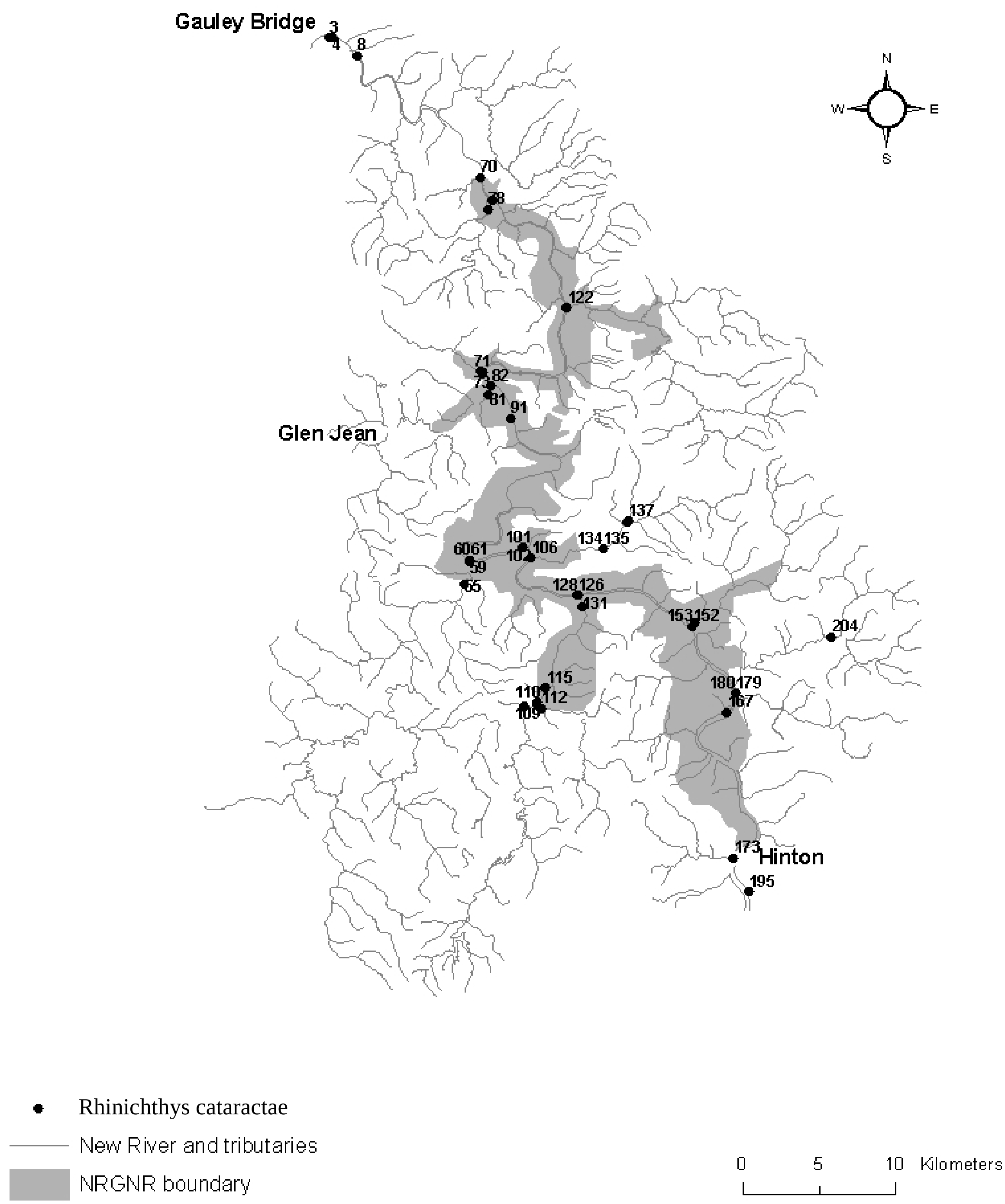

Figure 28. Collection sites for *Rhinichthys cataractae* (longnose dace) within or near the New River Gorge National River.

Semotilus atromaculatus (creek chub)

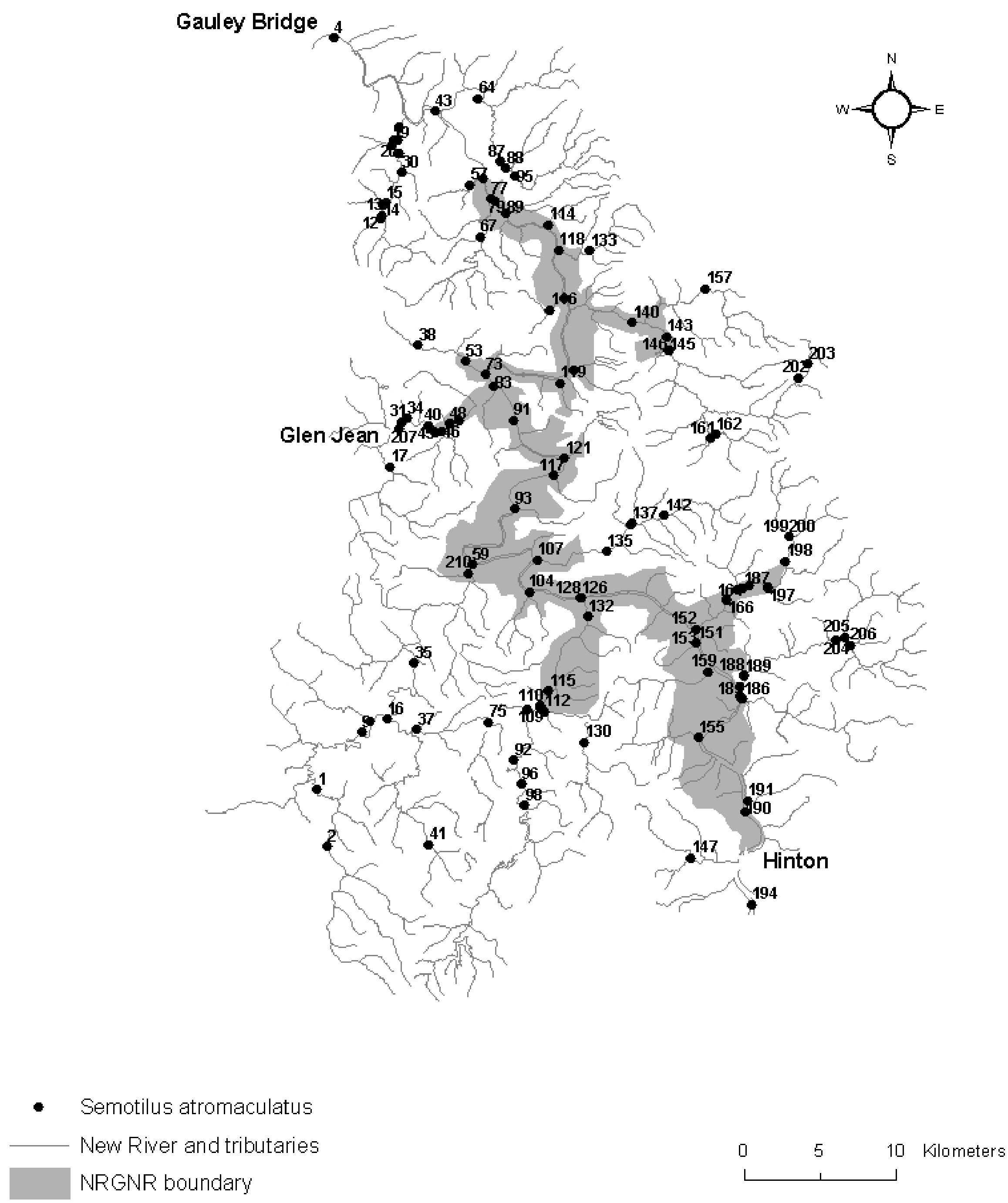

Figure 29. Collection sites for *Semotilus atromaculatus* (creek chub) within and near the New River Gorge National River.

Catostomus commersoni (white sucker)

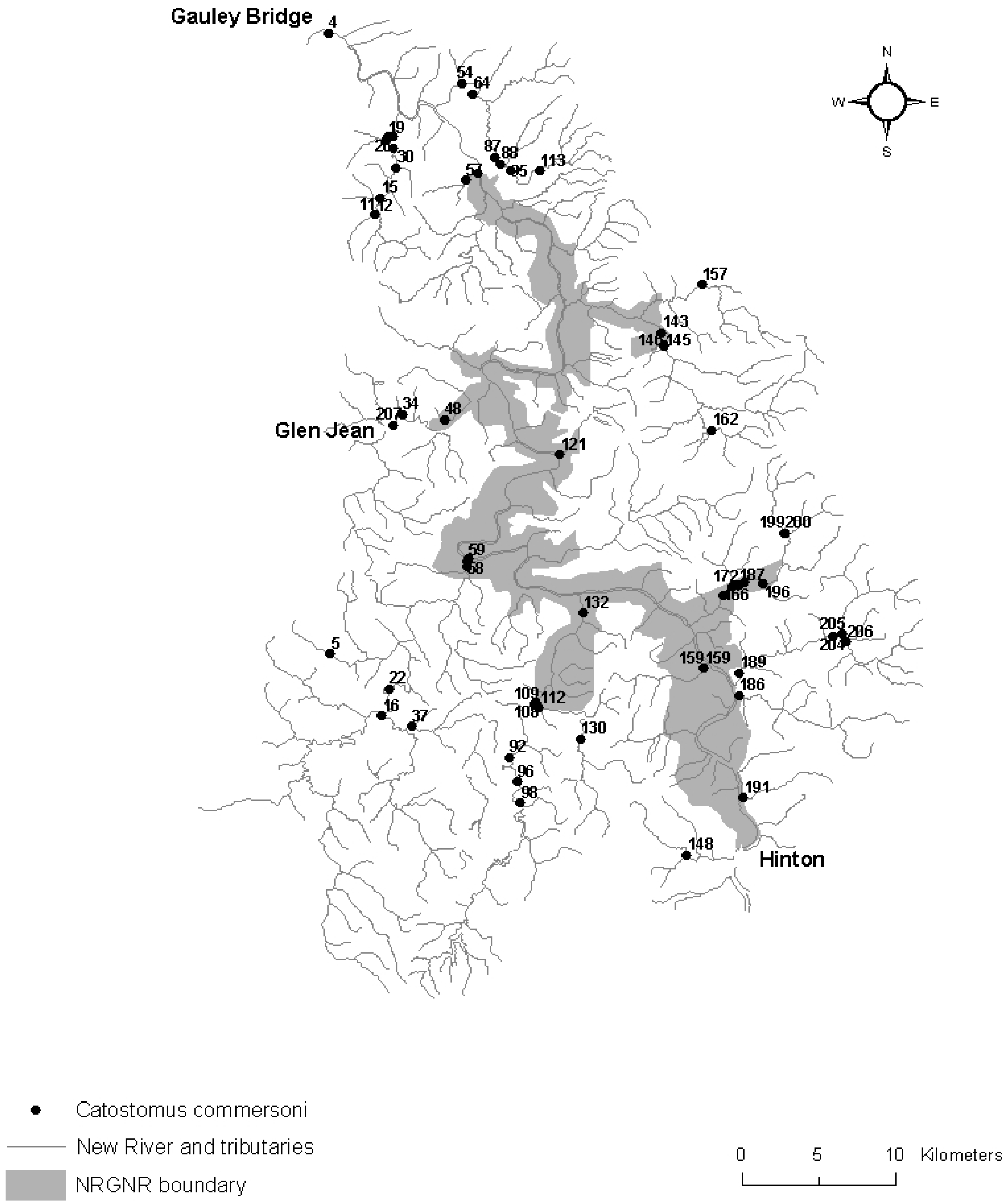

Figure 30. Collection sites for *Catostomus commersoni* (white sucker) within and near the New River Gorge National River.

Hypentelium nigricans (northern hogsucker)

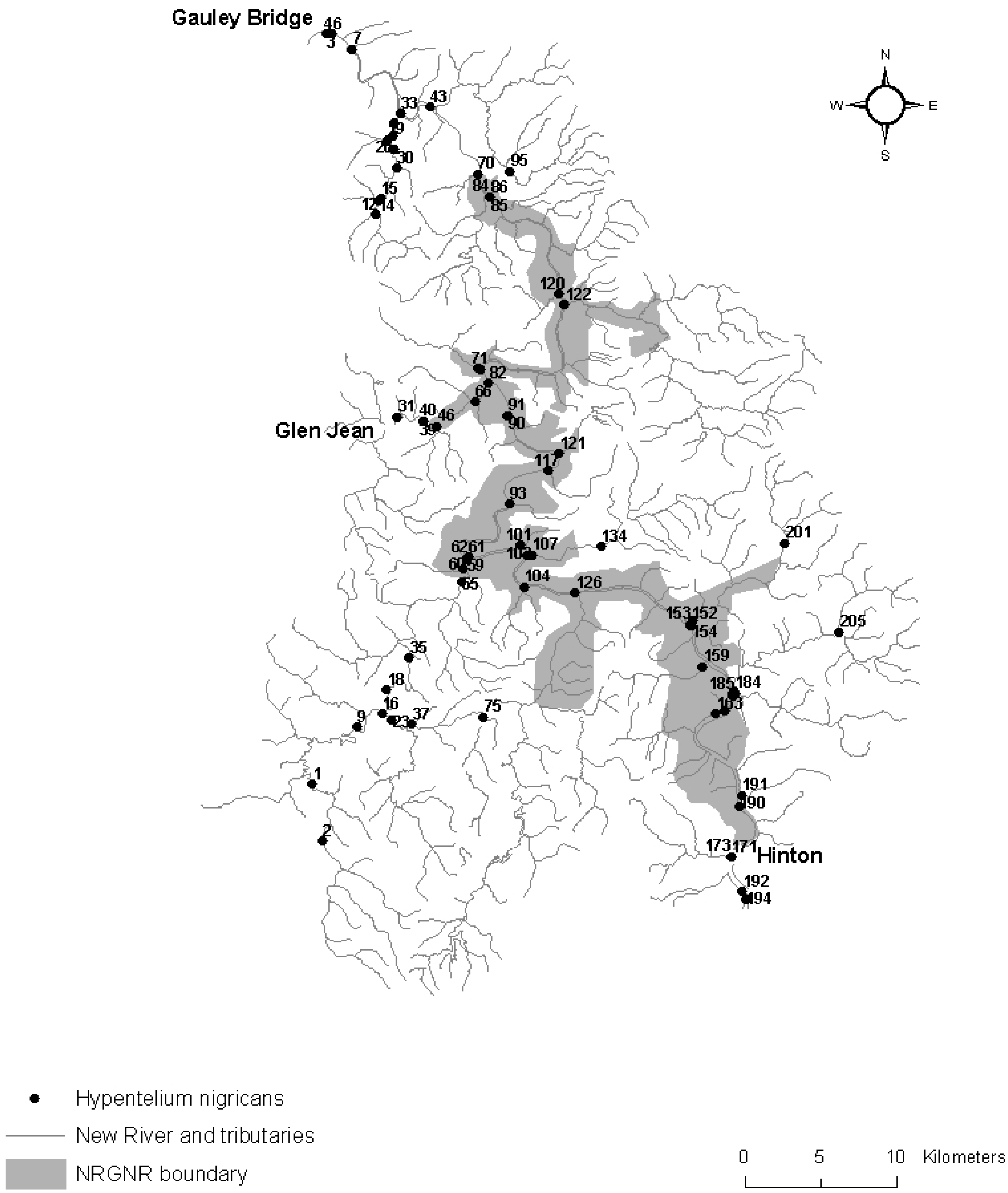

Figure 31. Collection sites for *Hypentelium nigricans* (northern hogsucker) within and near the New River Gorge National River.

Ameiurus natalis (yellow bullhead)

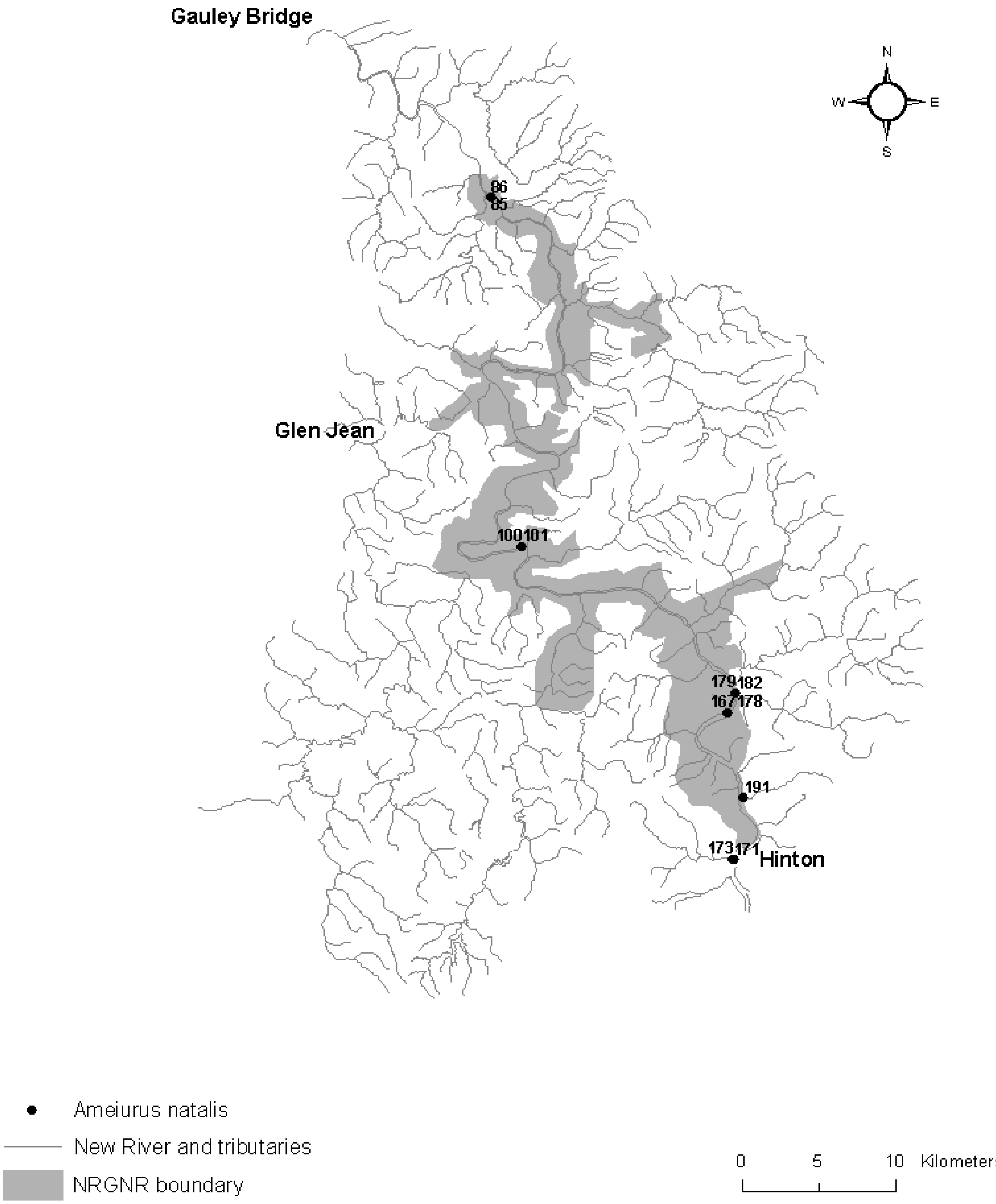

Figure 32. Collection sites for *Ameiurus natalis* (yellow bullhead) within and near the New River Gorge National River.

Ictalurus punctatus (channel catfish)

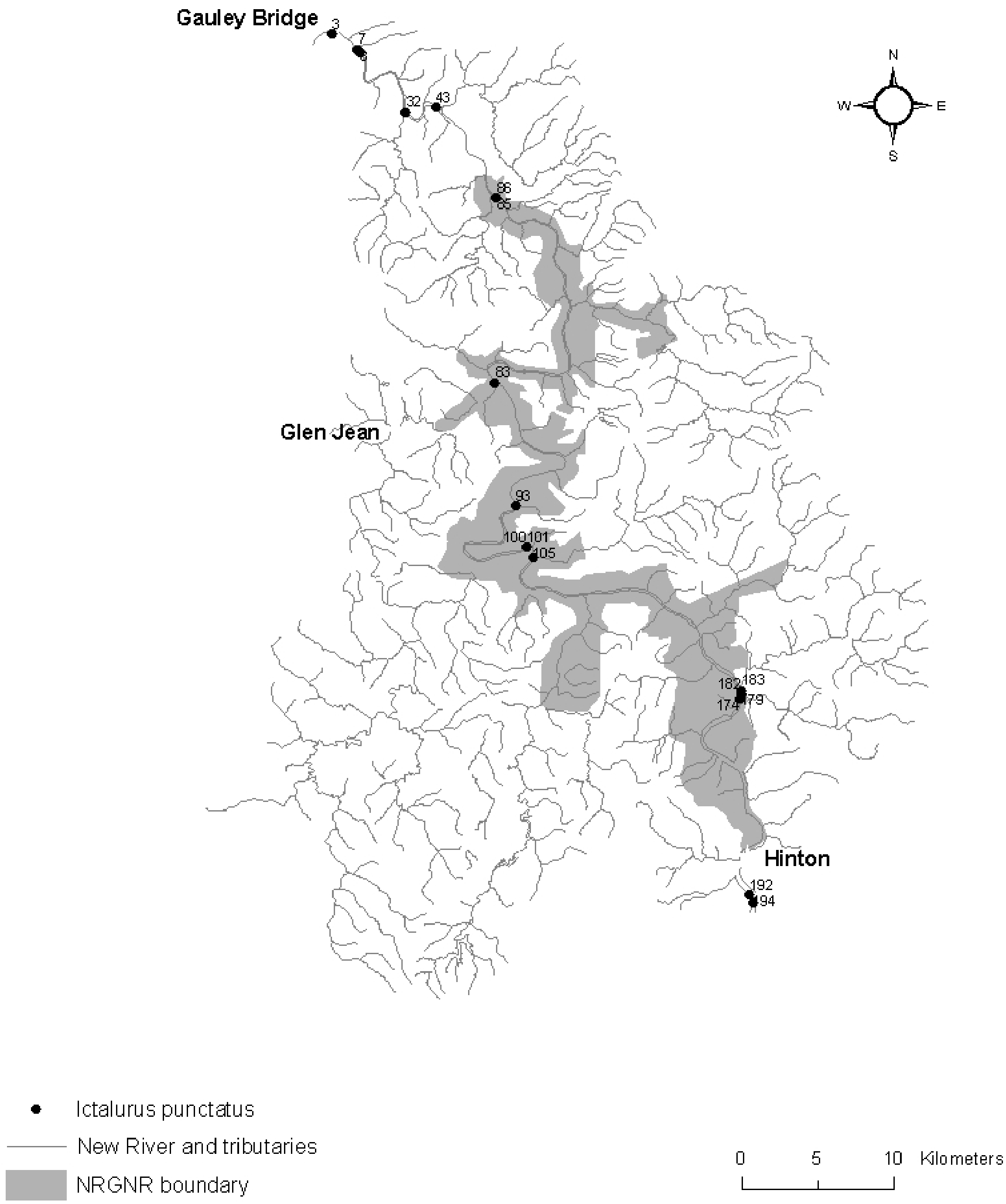

Figure 33. Collection sites for *Ictalurus punctatus* (channel catfish) within and near the New River Gorge National River.

Pylodictis olivaris (flathead catfish)

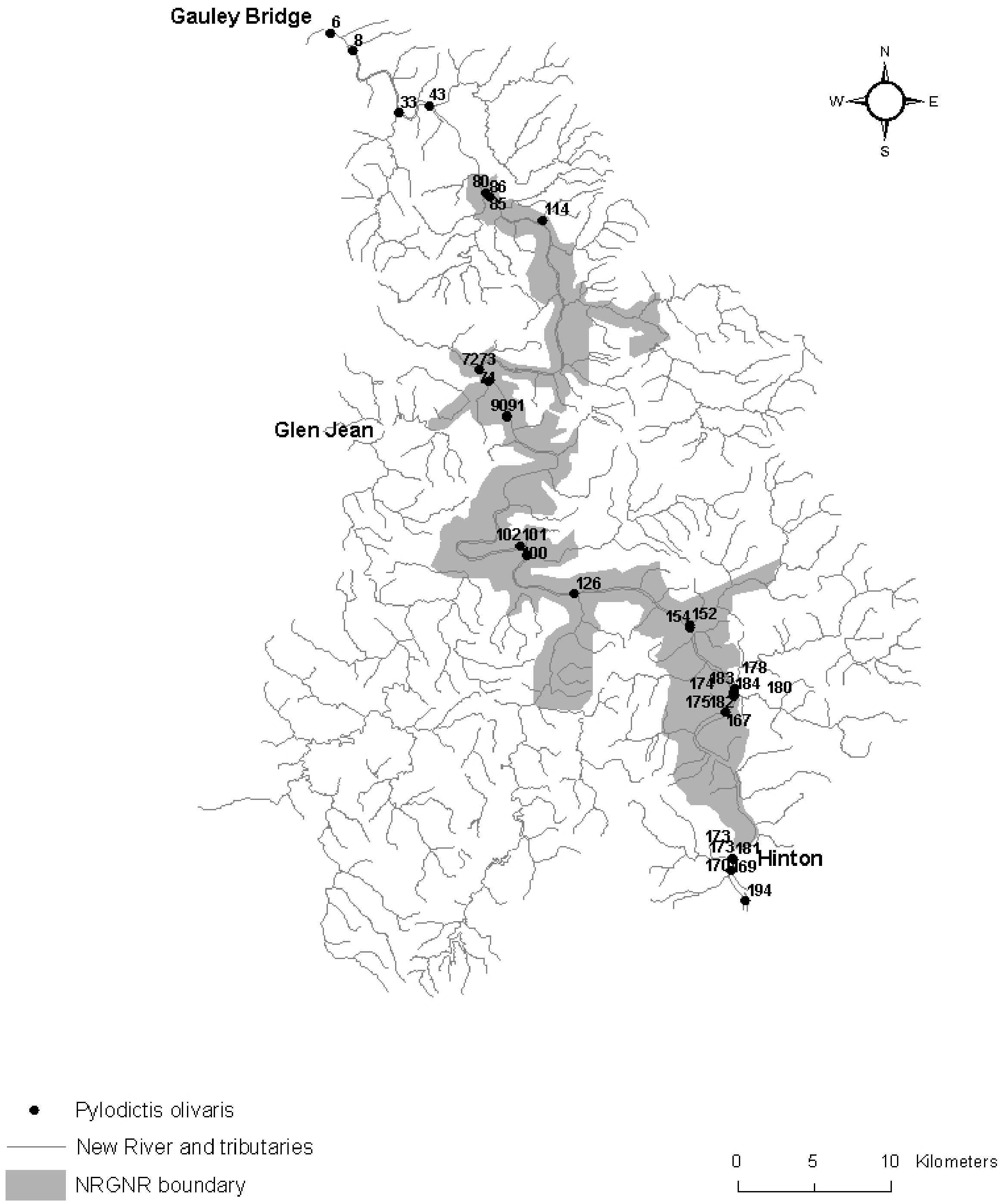

Figure 34. Collection sites for *Pylodictis olivaris* (flathead catfish) within and near the New River Gorge National River.

Labidesthes sicculus (brook silverside)

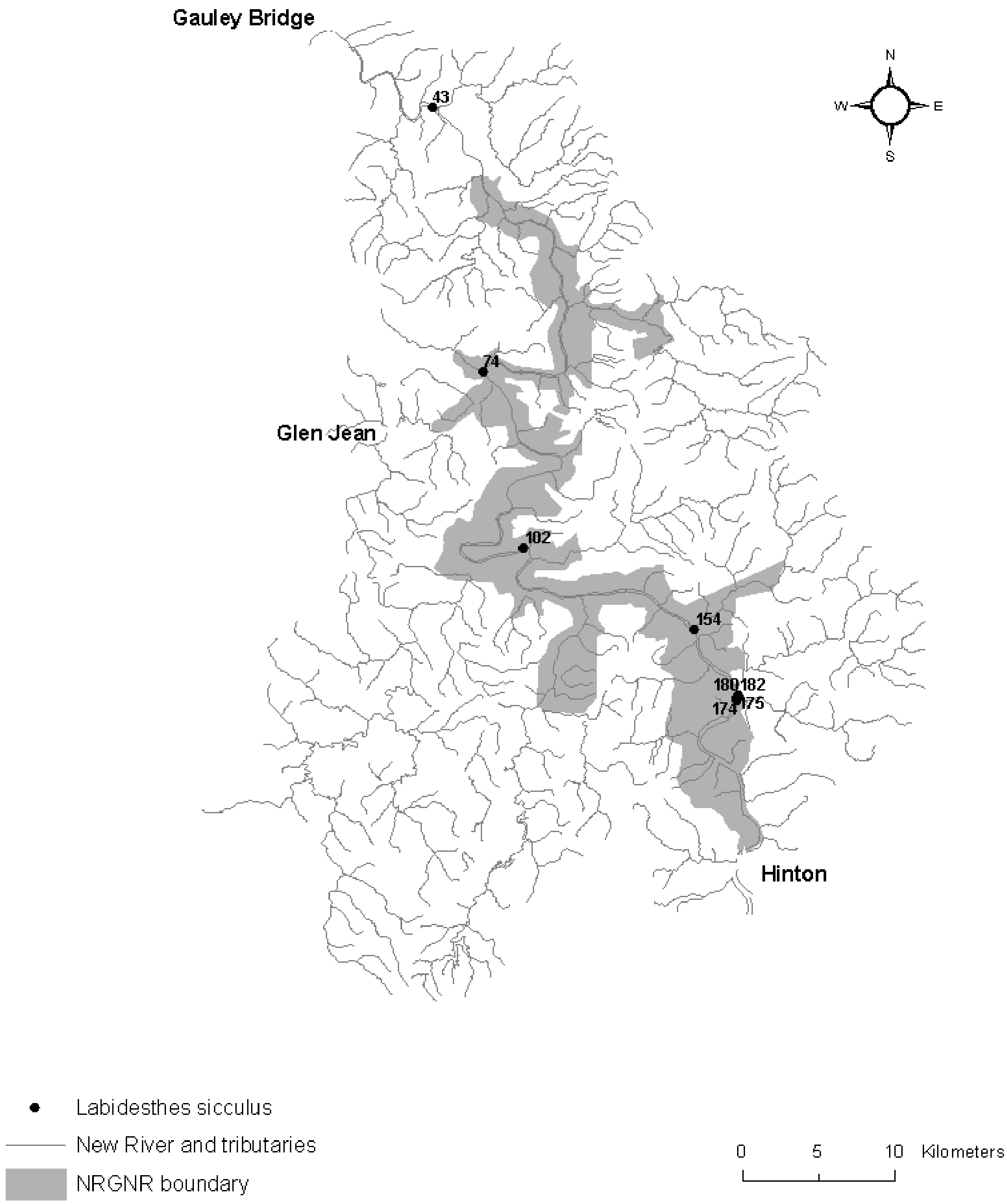

Figure 35. Collection sites for *Labidesthes sicculus* (brook silverside) within and near the New River Gorge National River.

Cottus bairdi (mottled sculpin)

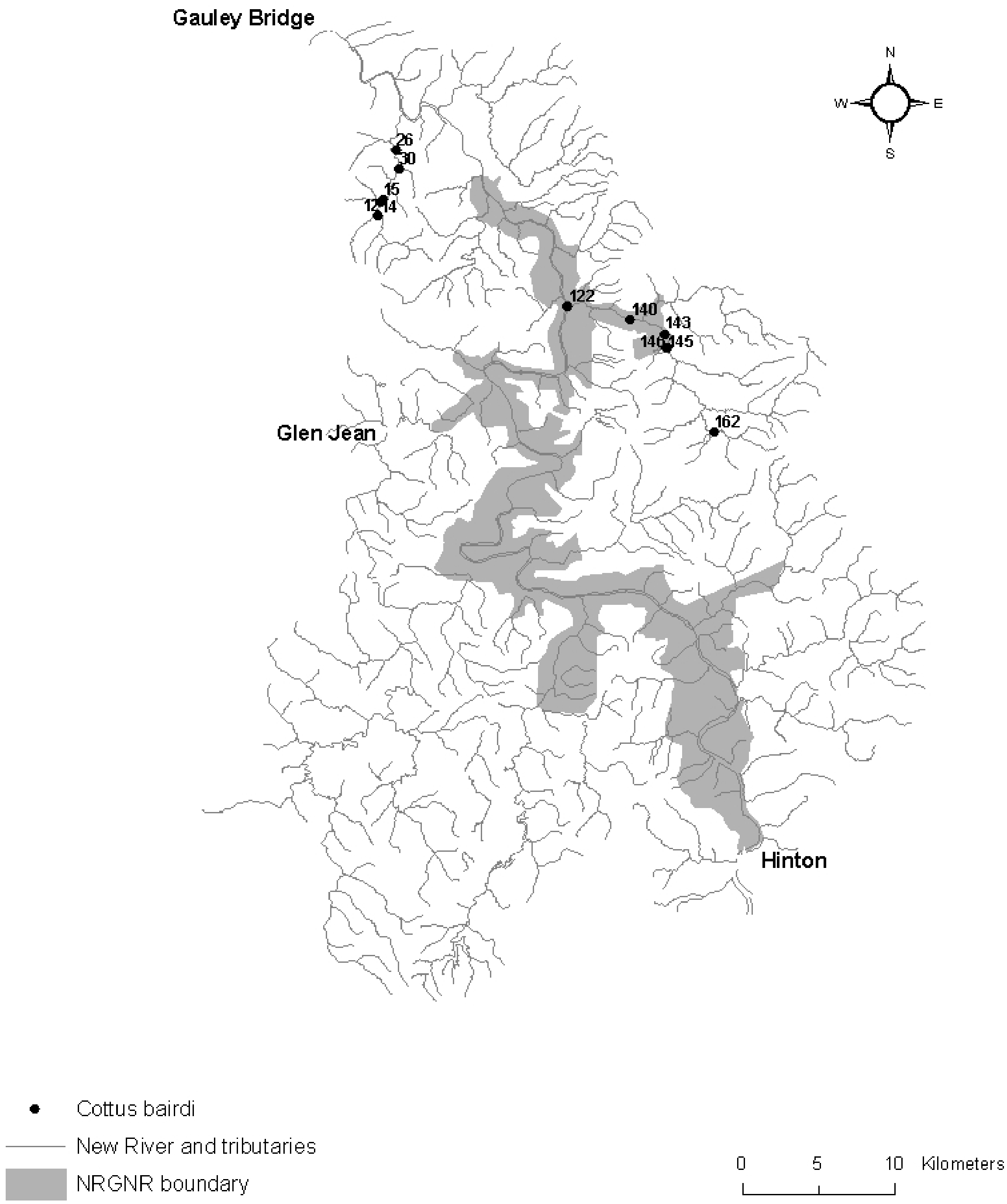

Figure 36. Collection sites for *Cottus bairdi* (mottled sculpin) within and near the New River Gorge National River.

Morone chrysops (white bass)

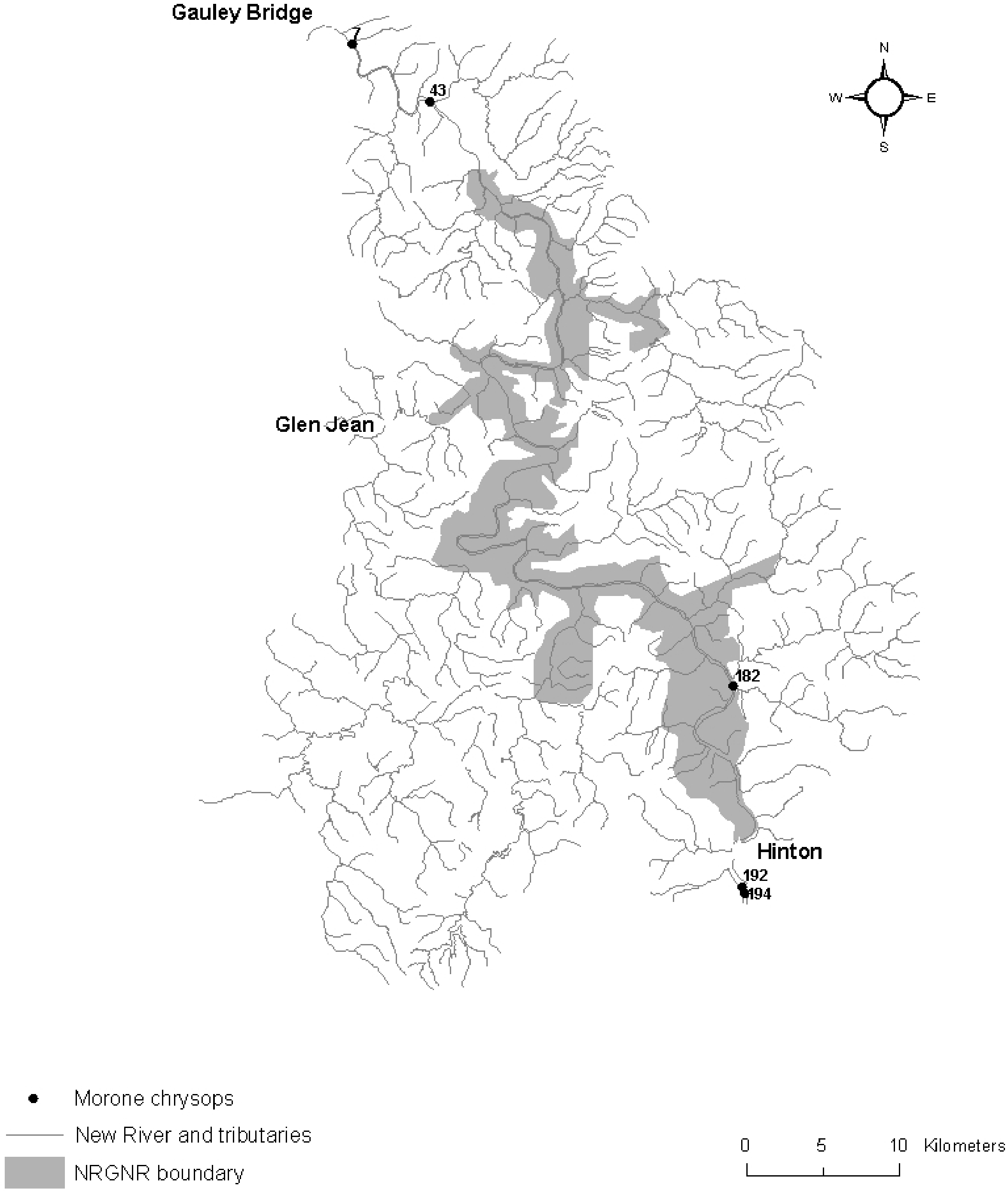

Figure 37. Collection sites for *Morone chrysops* (white bass) within and near the New River Gorge National River.

Oncorhynchus mykiss (rainbow trout)

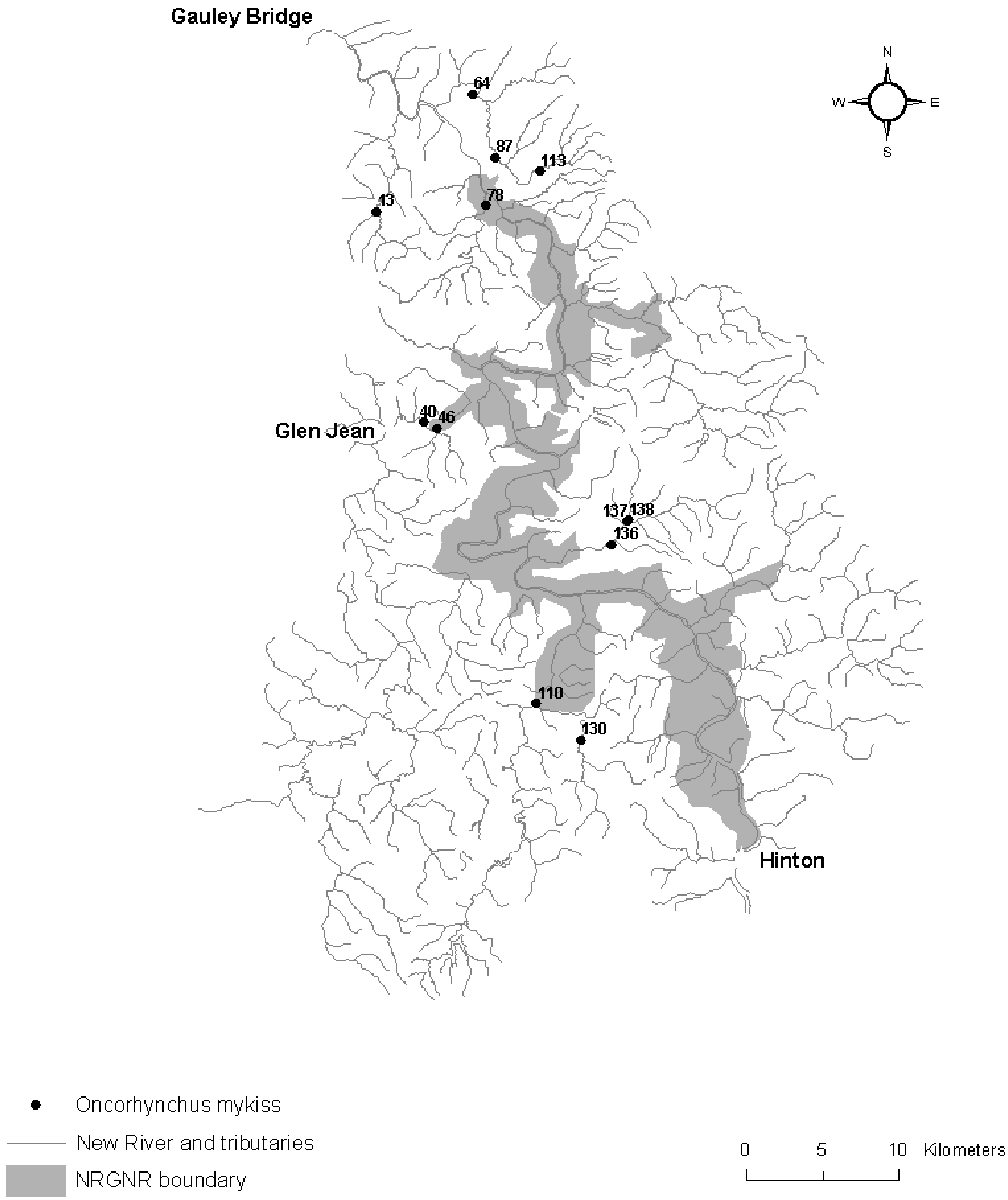

Figure 38. Collection sites for *Oncorhynchus mykiss* (rainbow trout) within and near the New River Gorge National River.

Salmo trutta (brown trout)

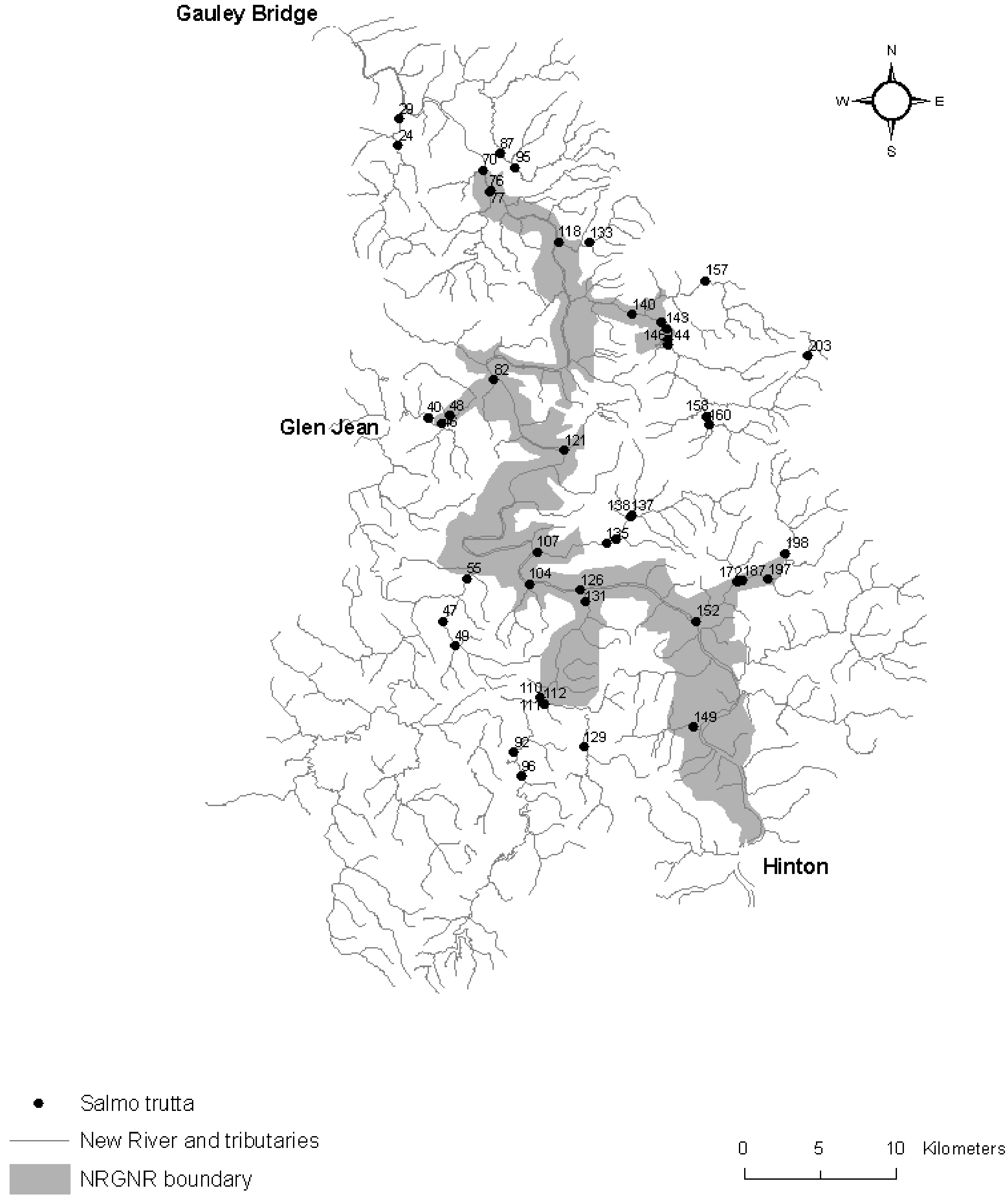

Figure 39. Collection sites for *Salmo trutta* (brown trout) within and near the New River Gorge National River.

Salvelinus fontinalis (brook trout)

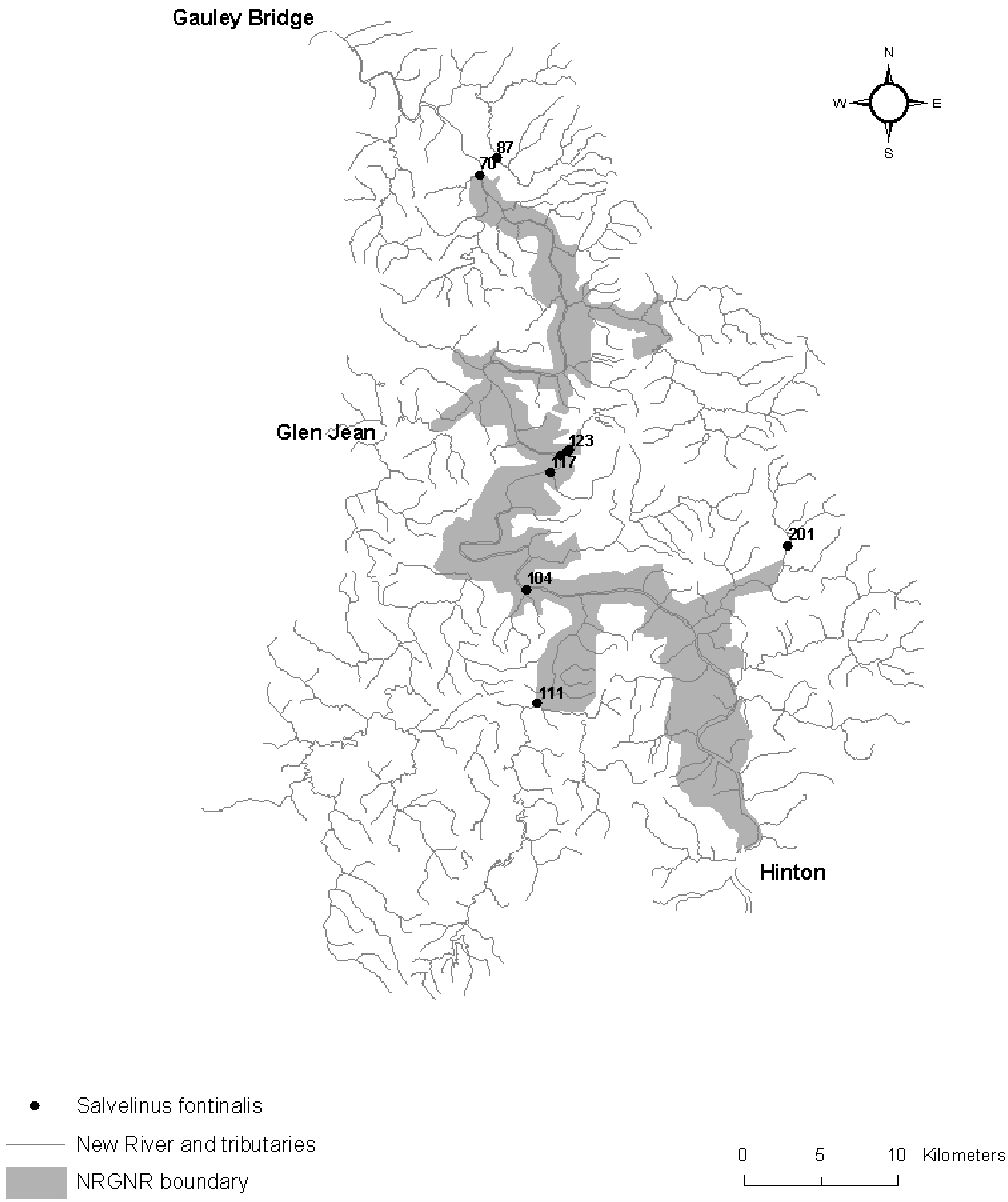

Figure 40. Collection sites for *Salvelinus fontinalis* (brook trout) within and near the New River Gorge National River.

Ambloplites rupestris (rock bass)

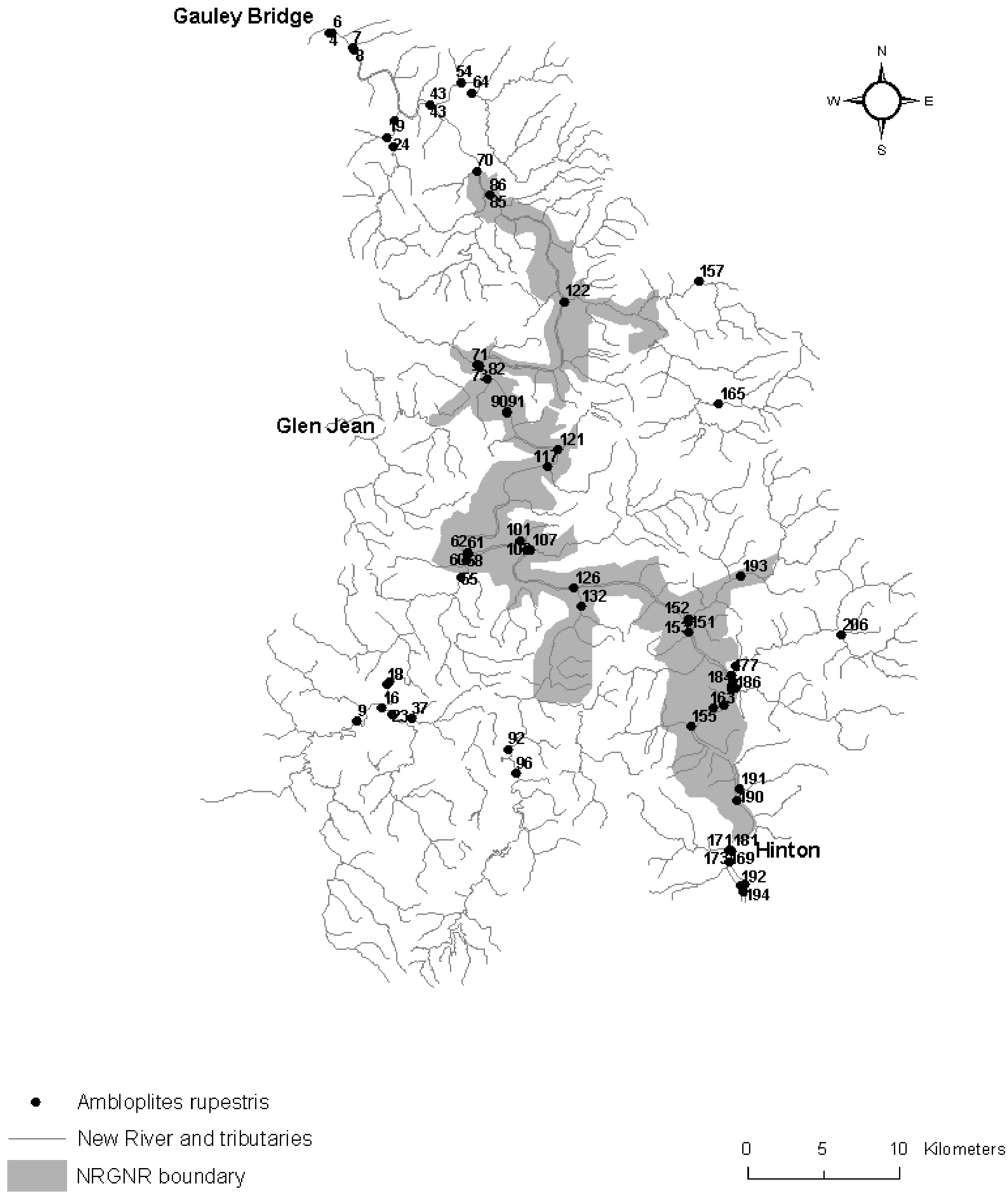

Figure 41. Collection sites for *Ambloplites rupestris* (rock bass) within and near the New River Gorge National River.

Lepomis auritus (redbreast sunfish)

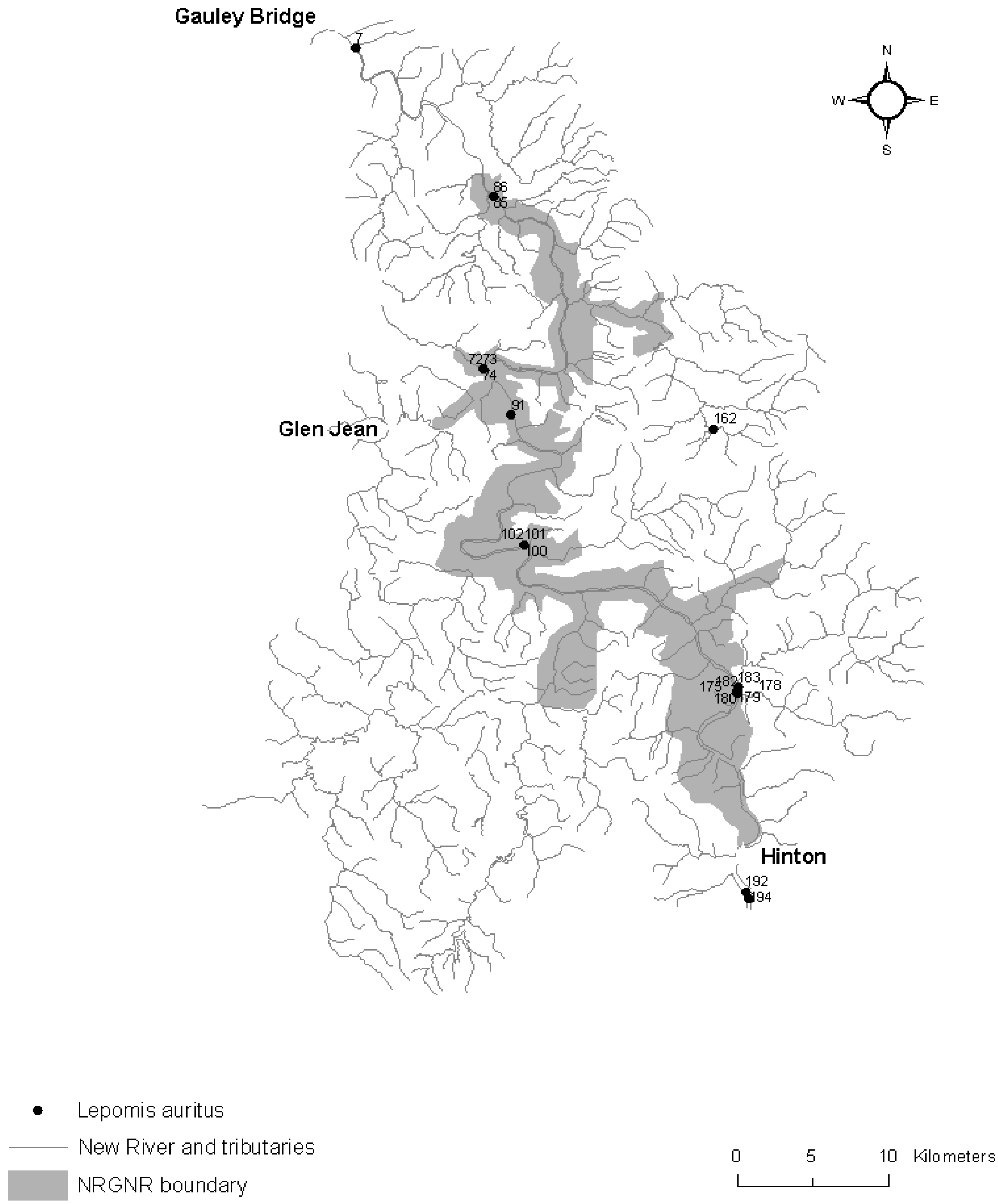

Figure 42. Collection sites for *Lepomis auritus* (redbreast sunfish) within and near the New River Gorge National River.

Lepomis cyanellus (green sunfish)

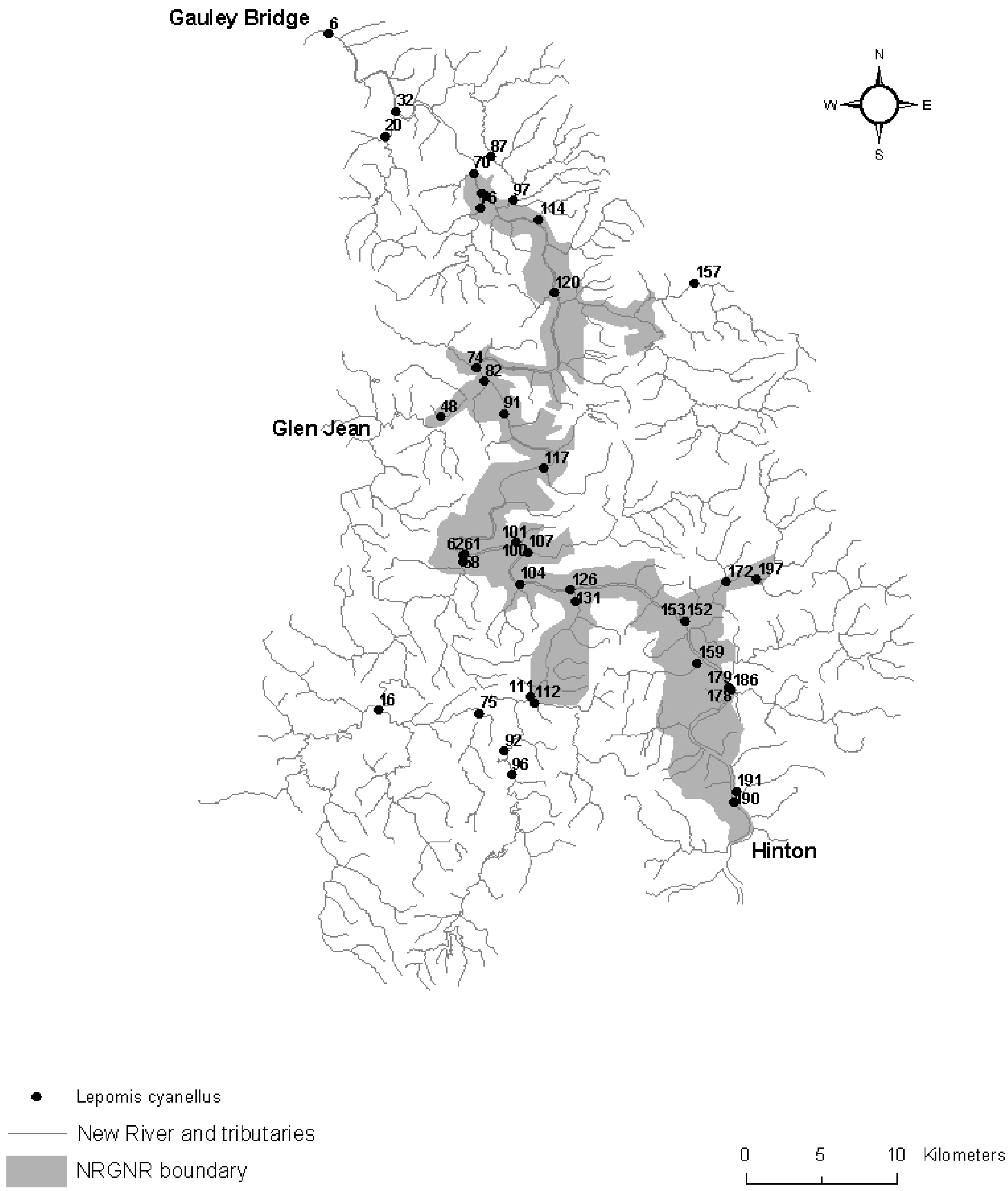

Figure 43. Collection sites for *Lepomis cyanellus* (green sunfish) within and near the New River Gorge National River

Lepomis gibbosus (pumpkinseed)

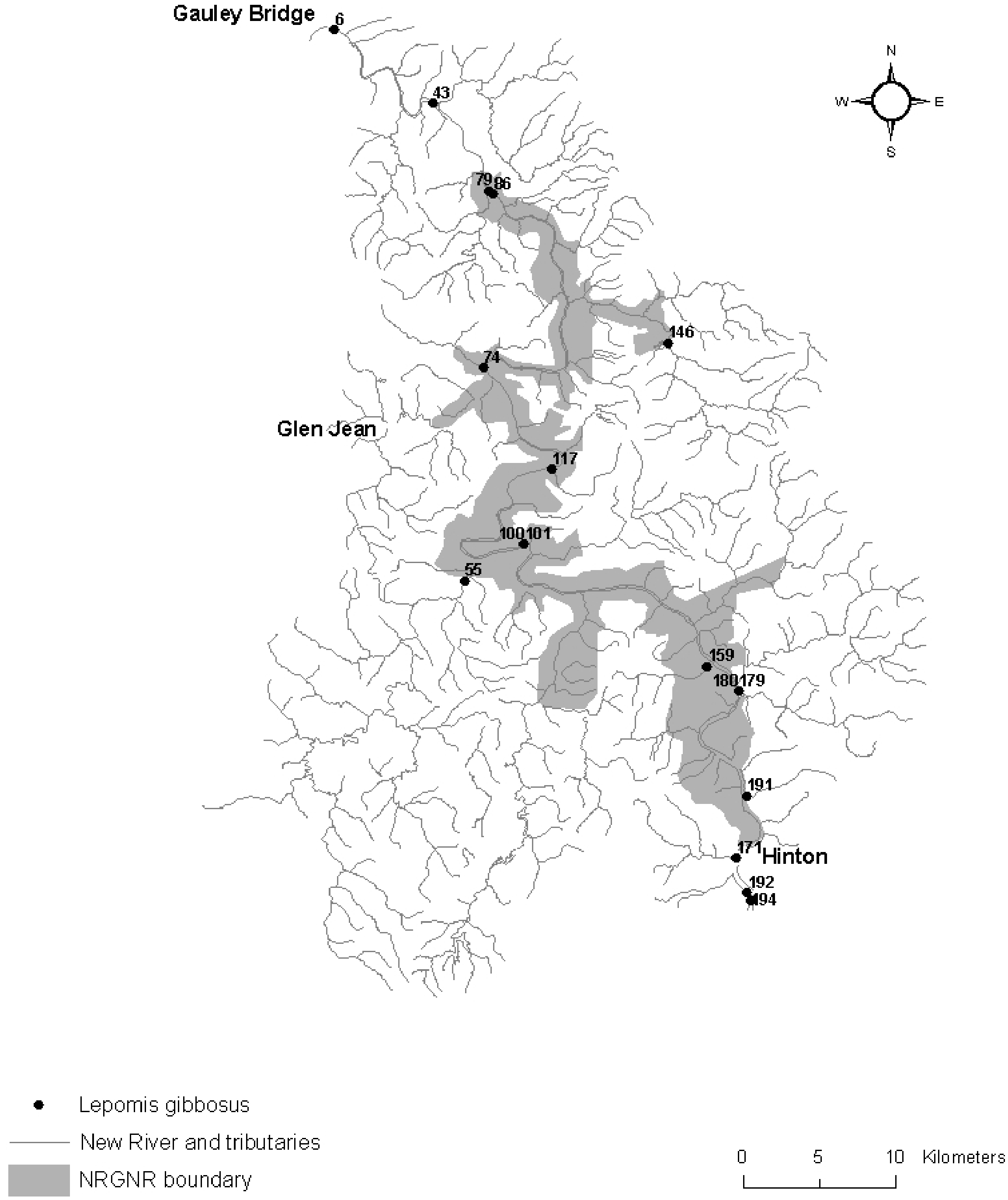

Figure 44. Collection sites for *Lepomis gibbosus* (pumpkinseed) within and near the New River Gorge National River.

Lepomis macrochirus (bluegill)

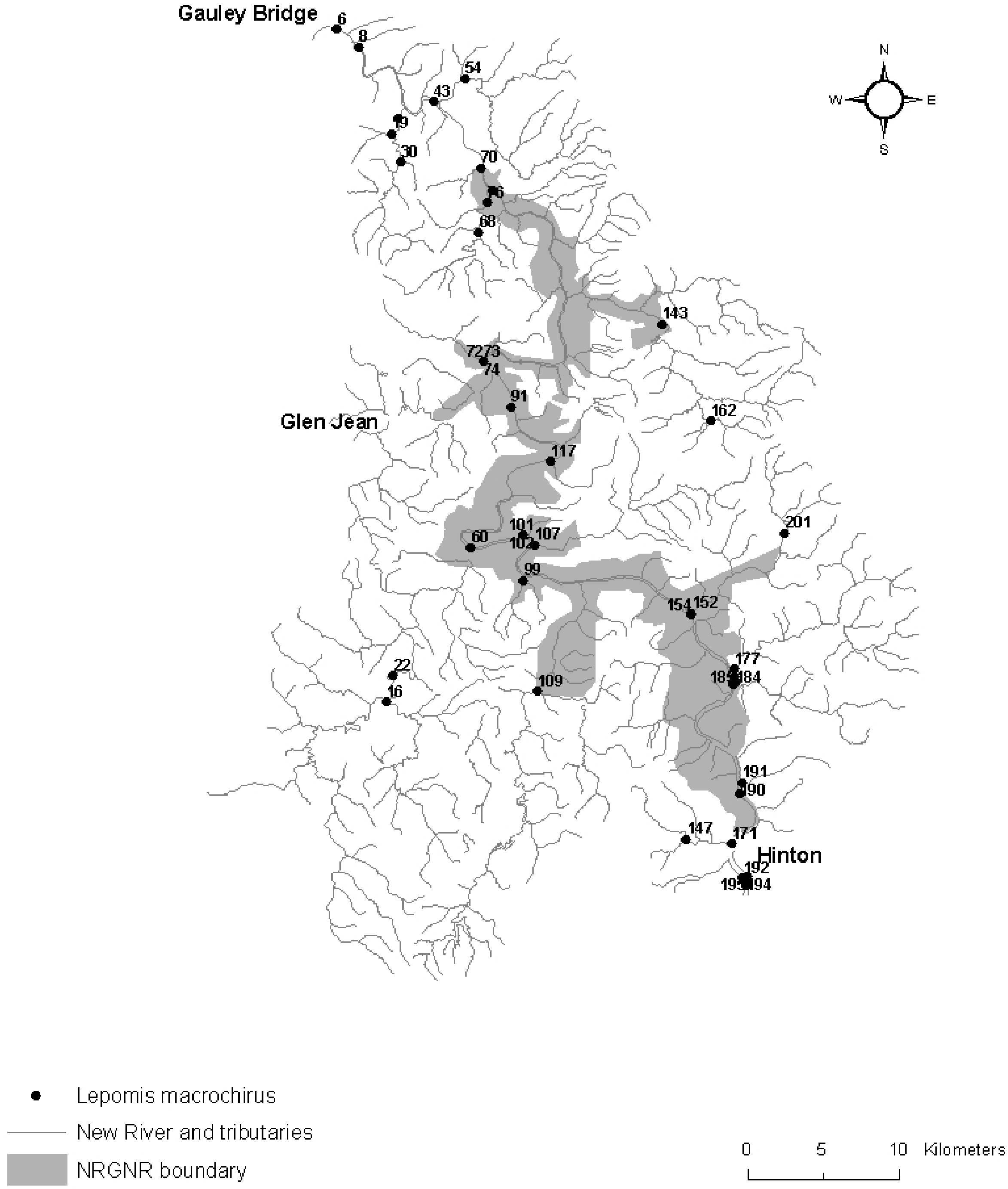

Figure 45. Collection sites for *Lepomis macrochirus* (bluegill) within and near the New River Gorge National River.

Lepomis megalotis (longear sunfish)

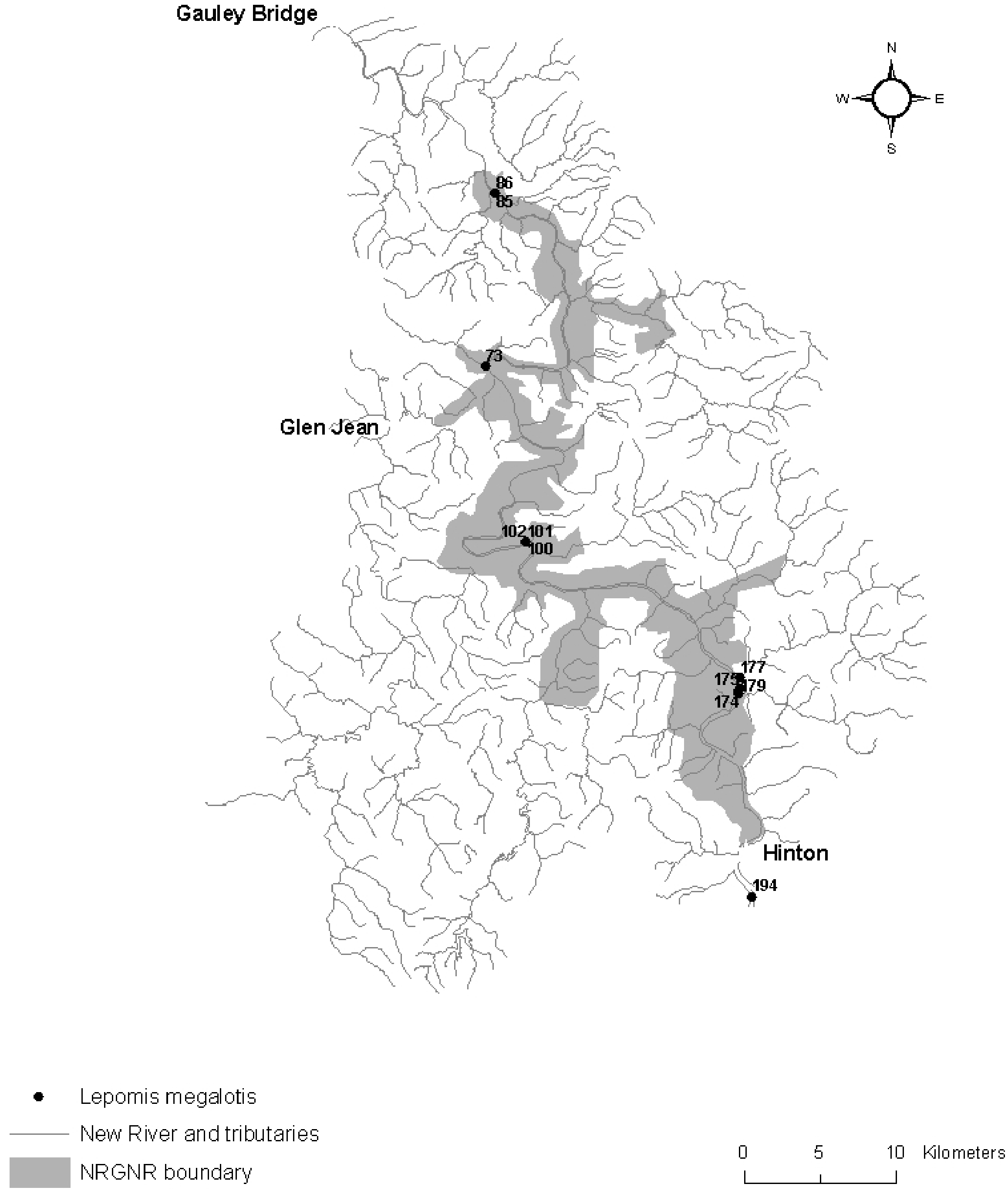

Figure 46. Collection sites for *Lepomis megalotis* (longear sunfish) within and near the New River Gorge National River.

Micropterus dolomieu (smallmouth bass)

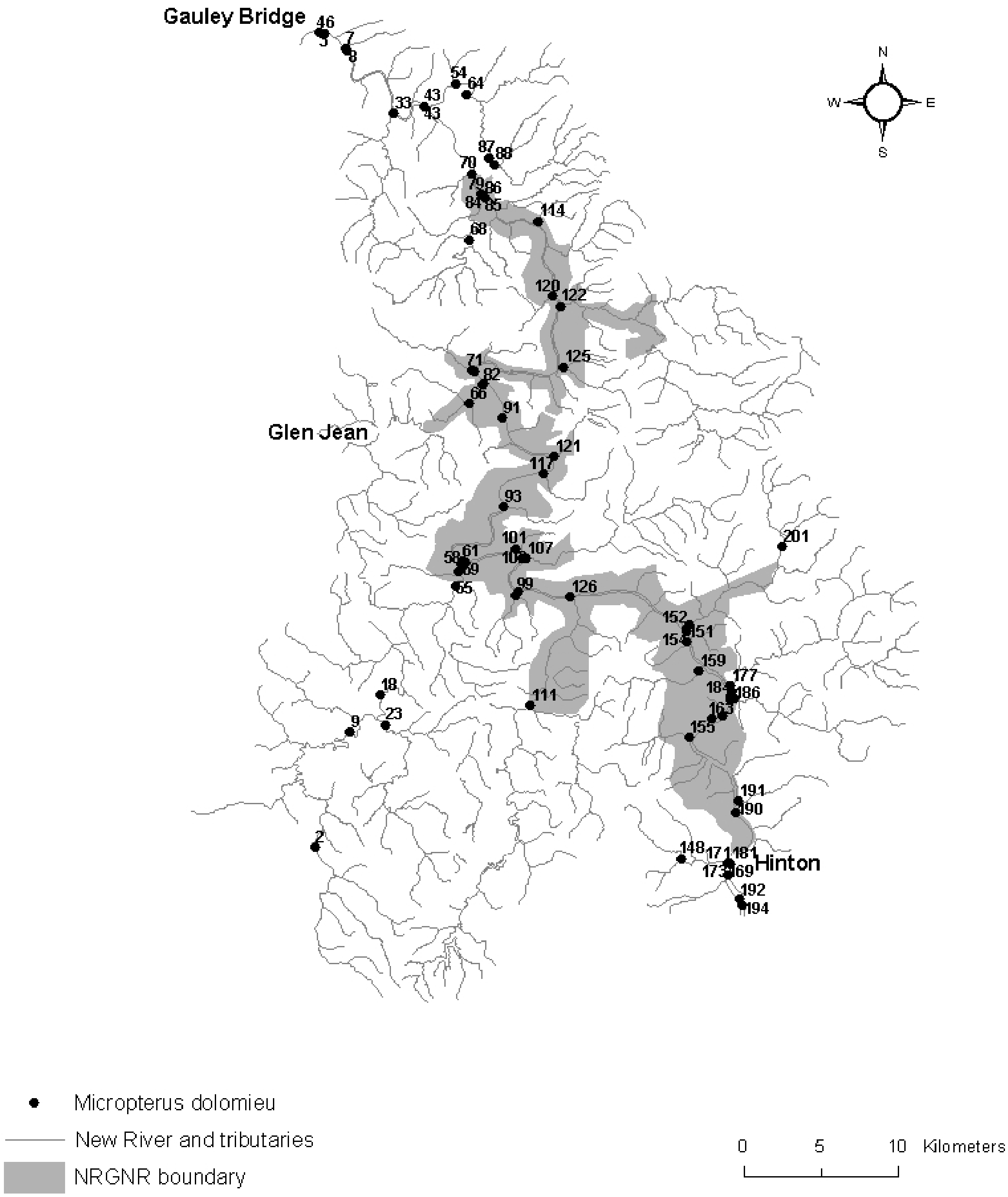

Figure 47. Collection sites for *Micropterus dolomieu* (smallmouth bass) within and near the New River Gorge National River.

Micropterus punctulatus (spotted bass)

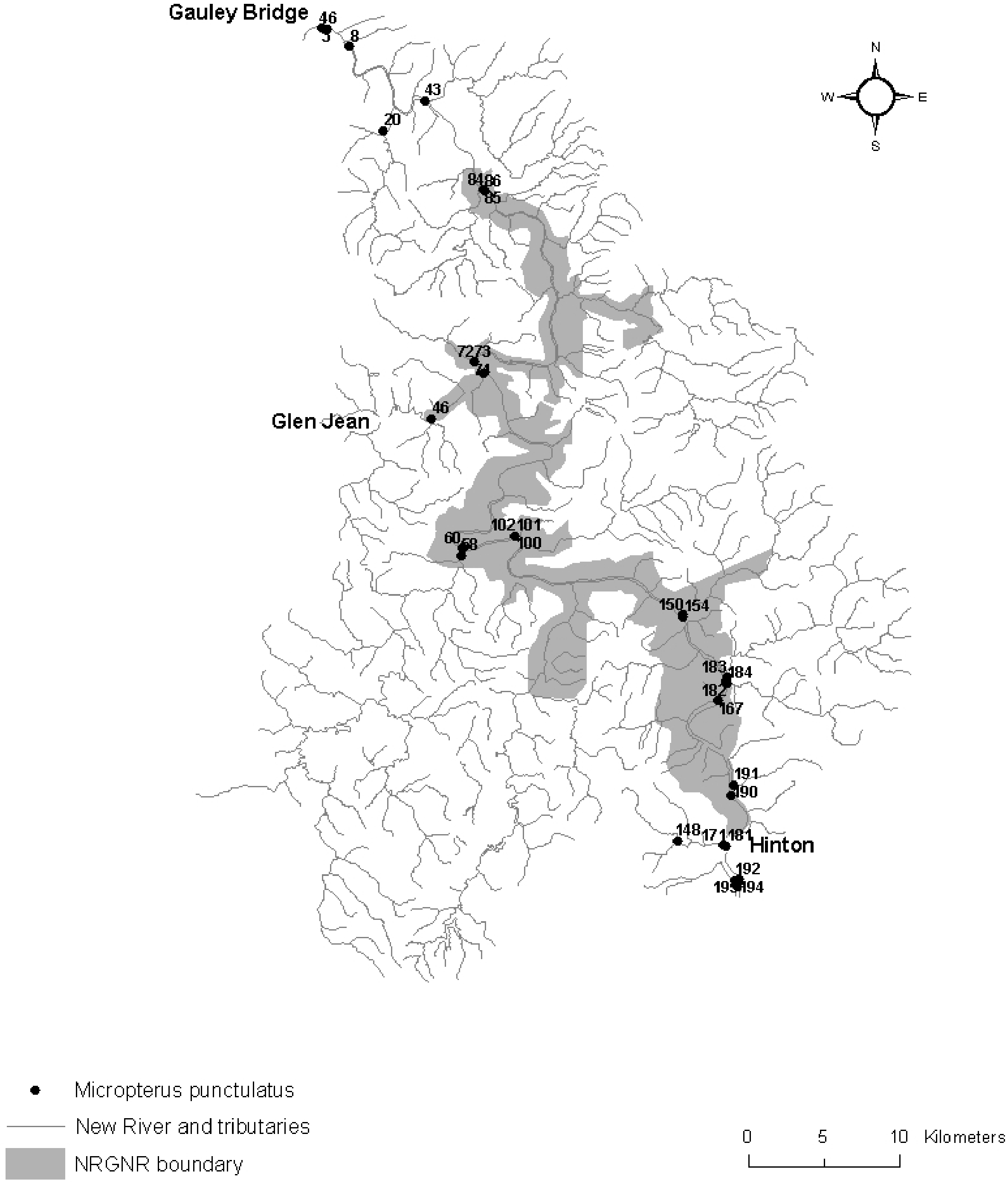

Figure 48. Collection sites for *Micropterus punctulatus* (spotted bass) within and near the New River Gorge National River.

Micropterus salmoides (largemouth bass)

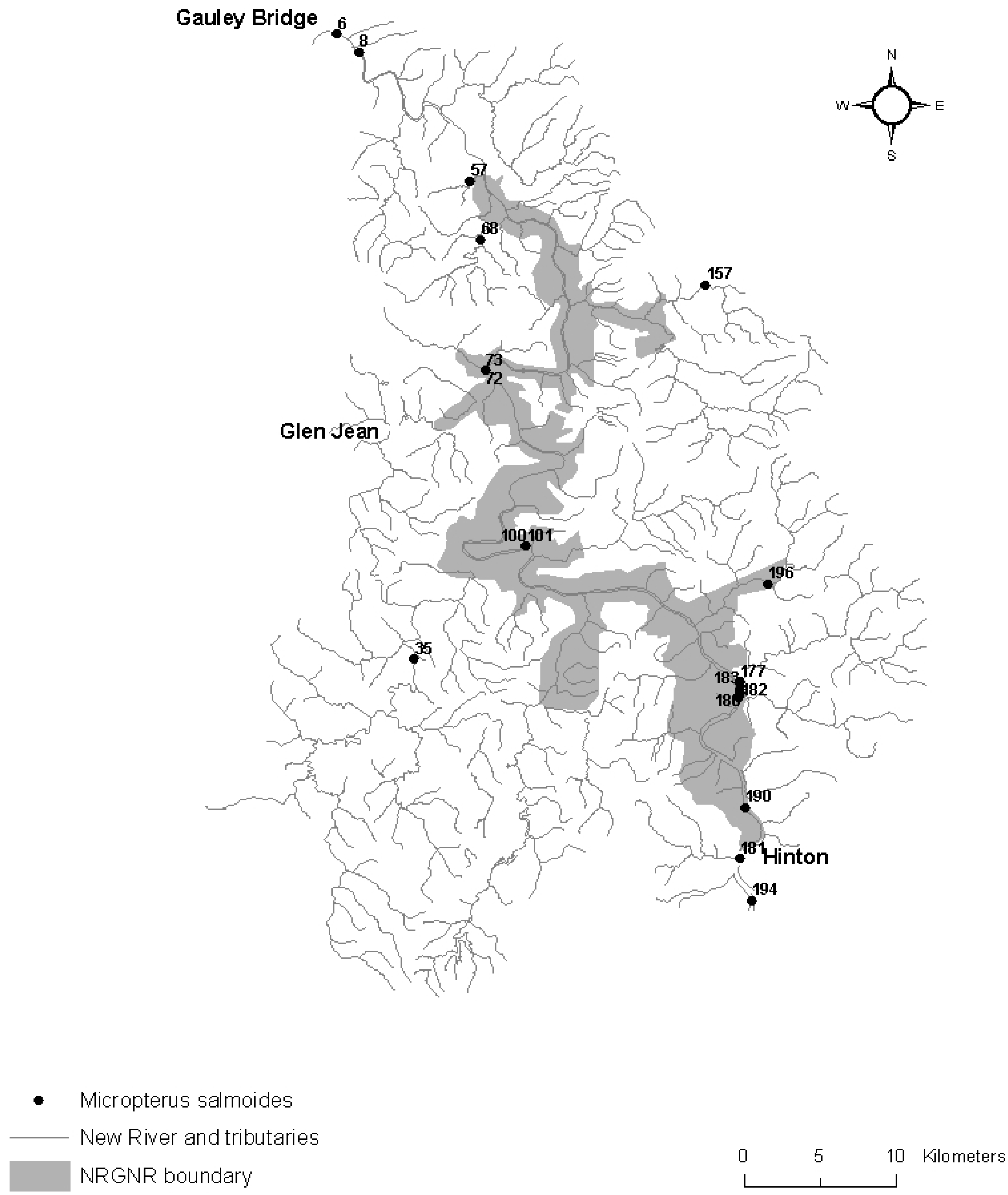

Figure 49. Collection sites for *Micropterus salmoides* (largemouth bass) within and near the New River Gorge National River.

Pomoxis annularis (white crappie)

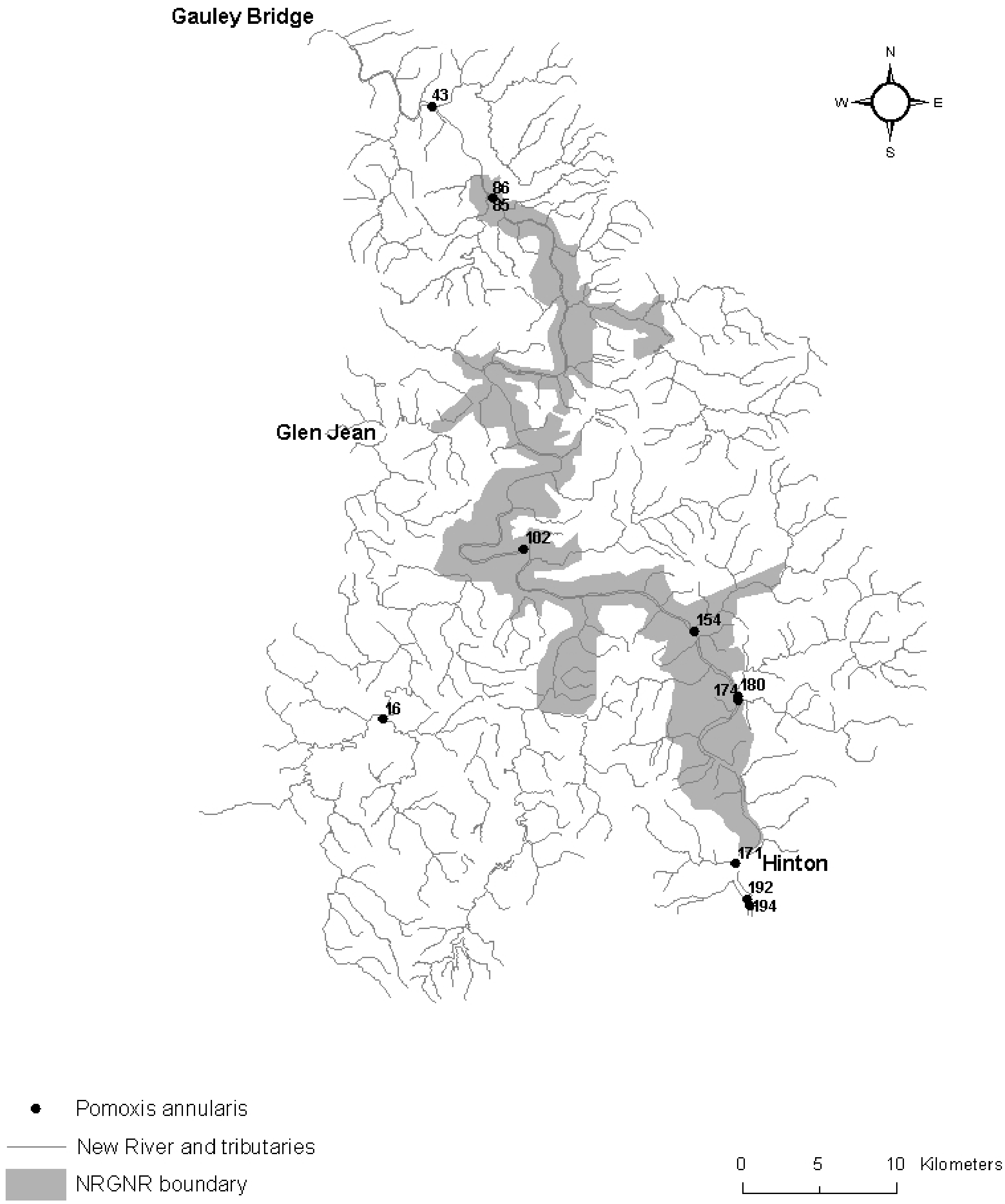

Figure 50. Collection sites for *Pomoxis annularis* (white crappie) within and near the New River Gorge National River.

Pomoxis nigromaculatus (black crappie)

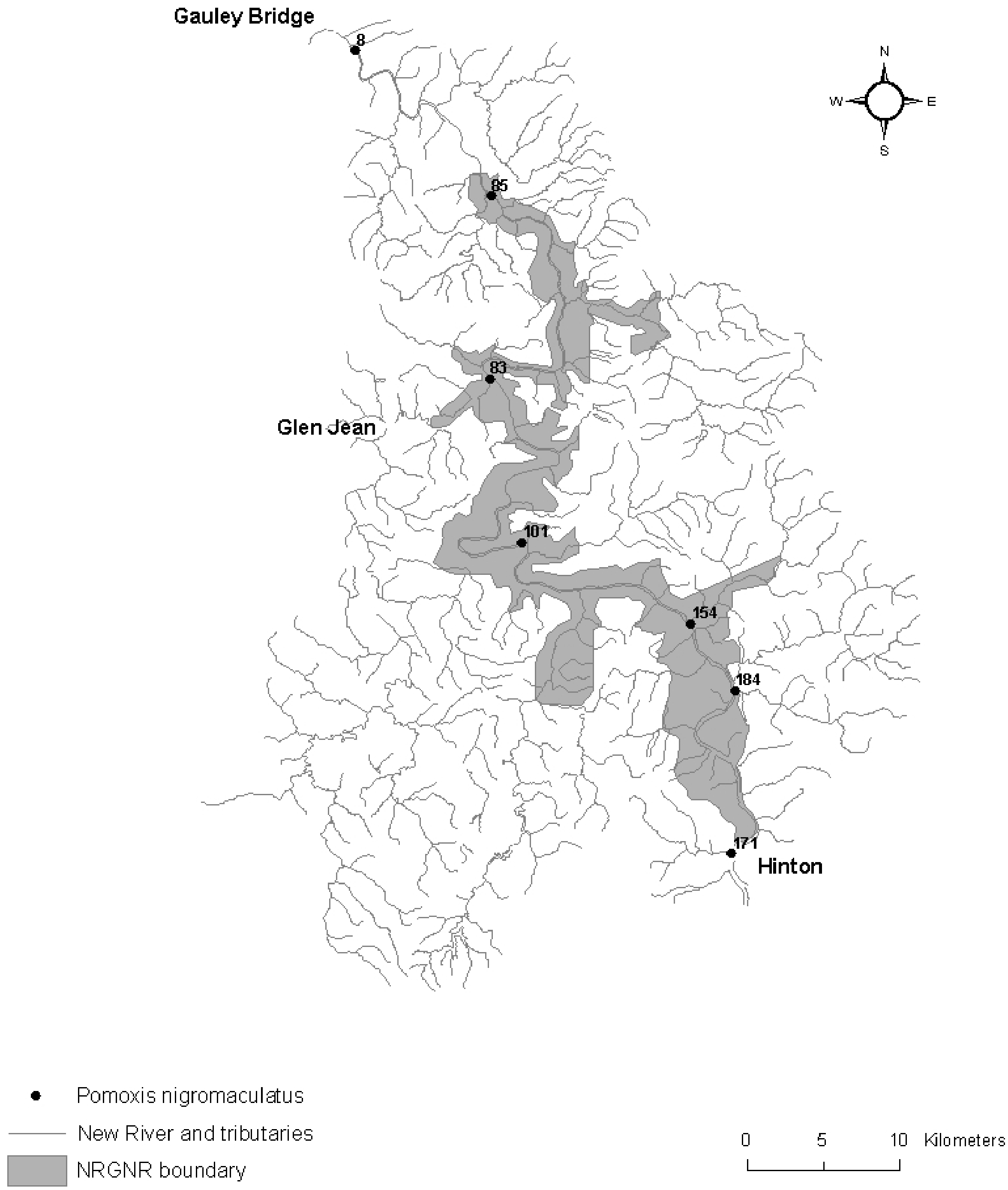

Figure 51. Collection sites for *Pomoxis nigromaculatus* (black crappie) within and near the New River Gorge National River.

Etheostoma blennioides (greenside darter)

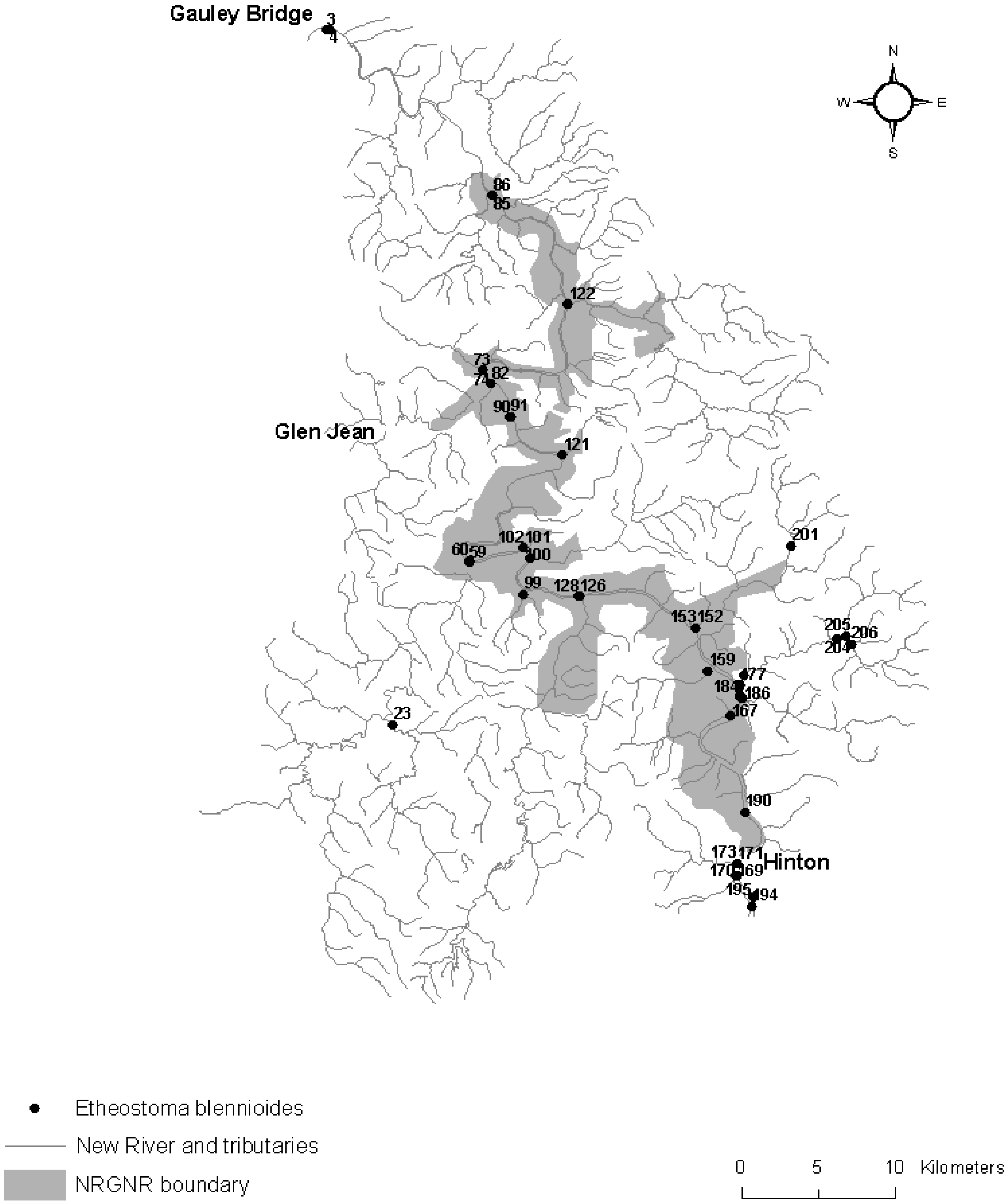

Figure 52. Collection sites for *Etheostoma blennioides* (greenside darter) within and near the New River Gorge National River.

Etheostoma caeruleum (rainbow darter)

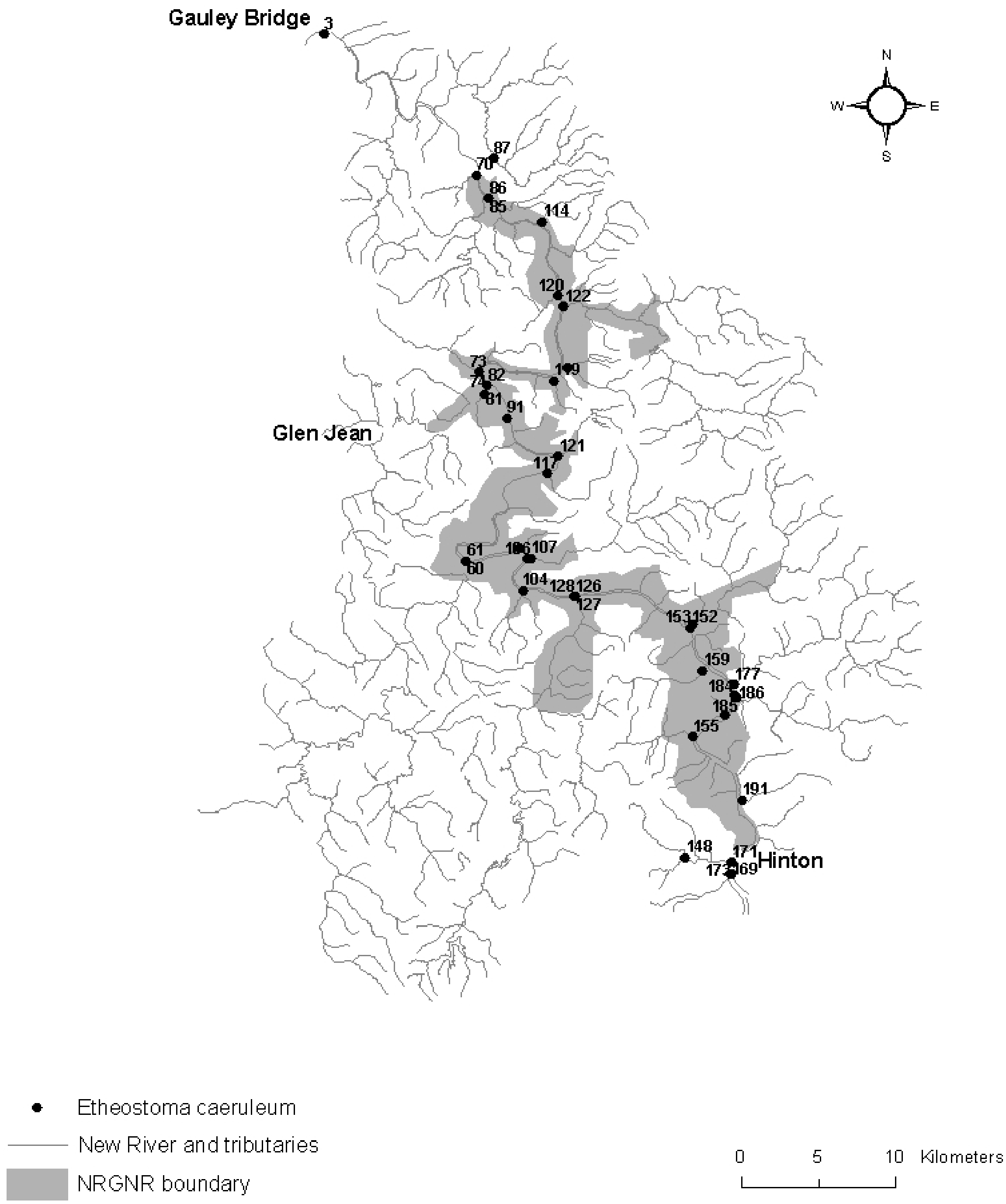

Figure 53. Collection sites for *Etheostoma caeruleum* (rainbow darter) within and near the New River Gorge National River.

Etheostoma flabellare (fantail darter)

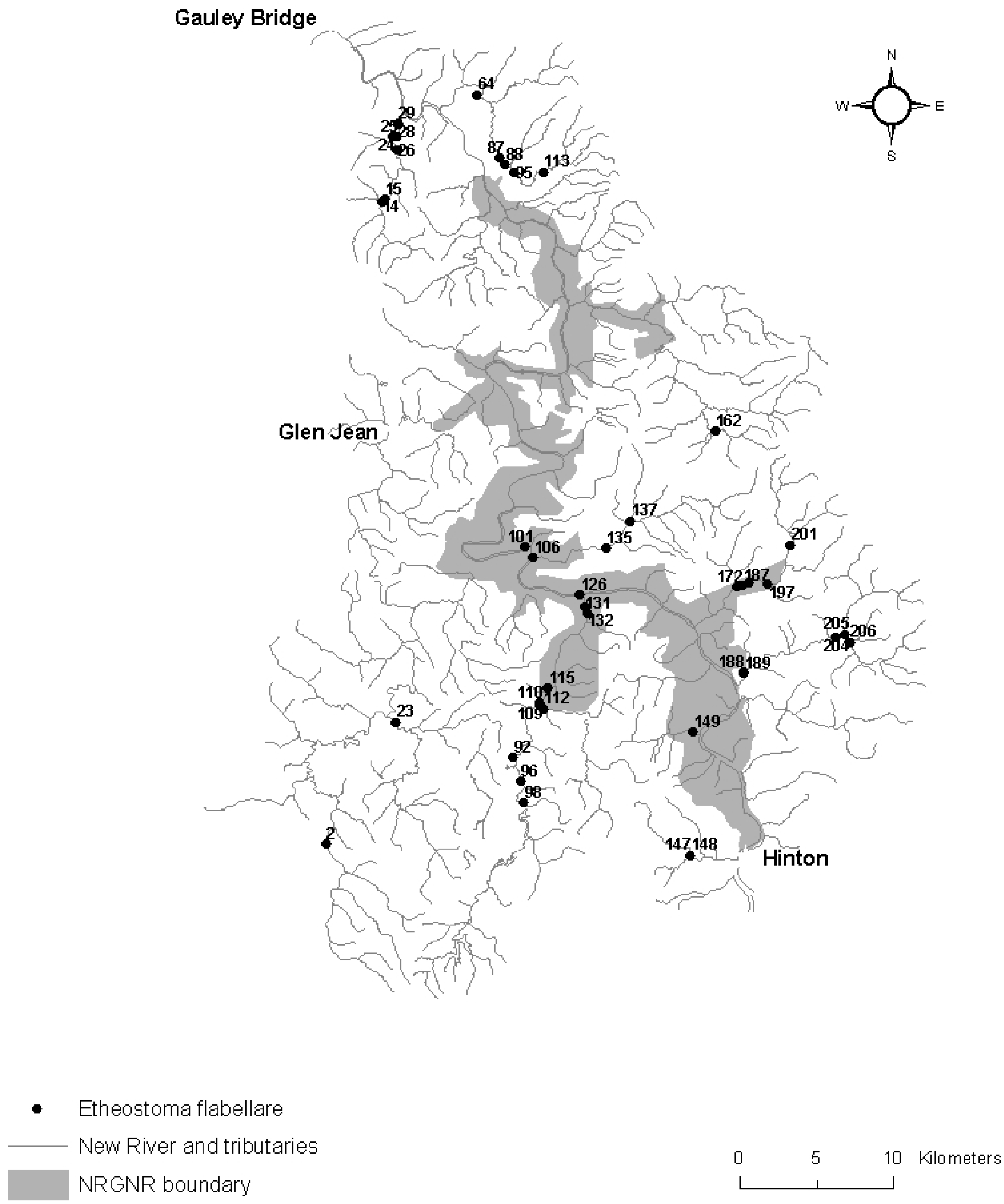

Figure 54. Collection sites for *Etheostoma flabellare* (fantail darter) within and near the New River Gorge National River.

Etheostoma nigrum (johnny darter)

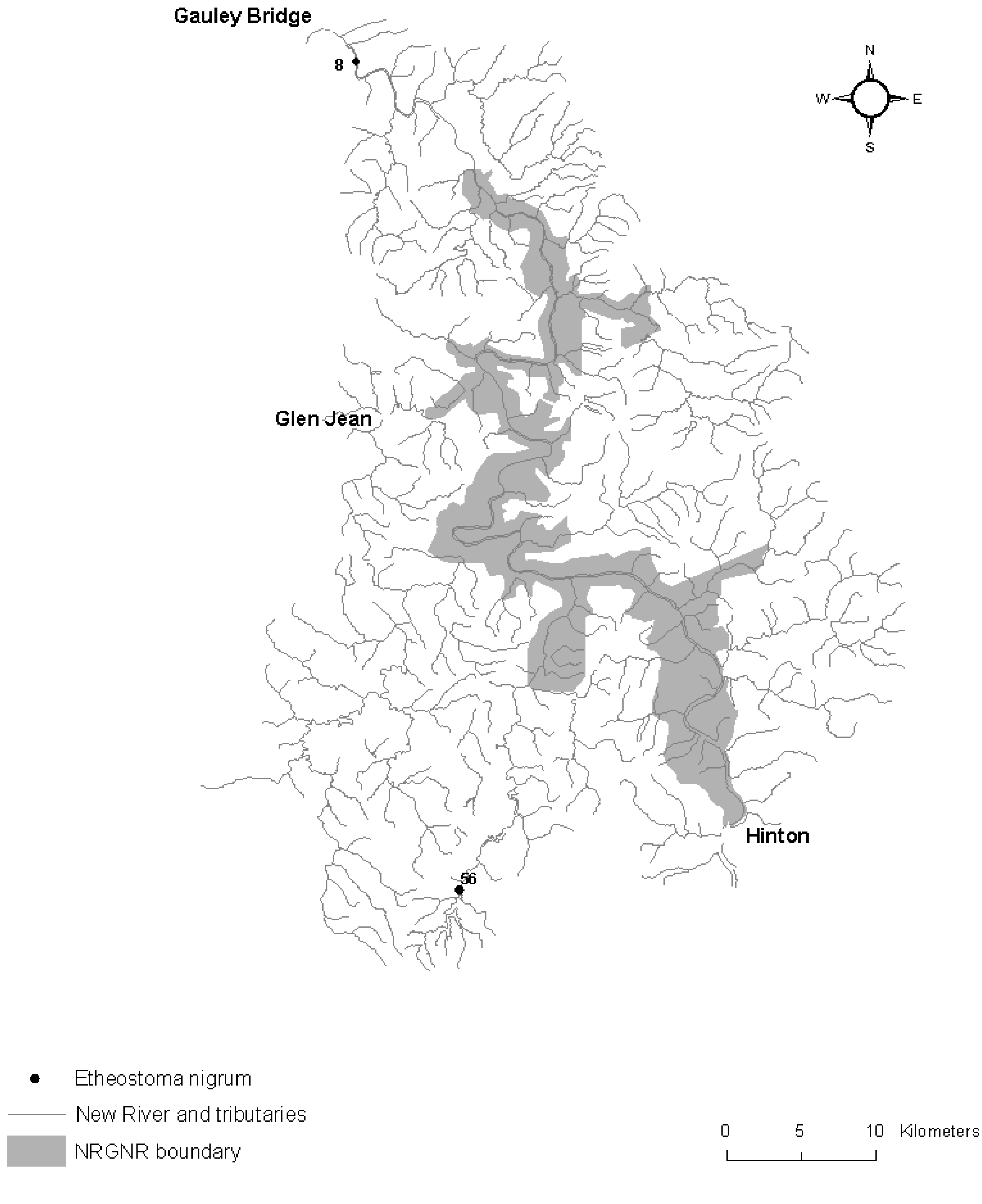

Figure 55. Collection sites for *Etheostoma nigrum* (johnny darter) within and near the New River Gorge National River.

Etheostoma variatum (variegate darter)

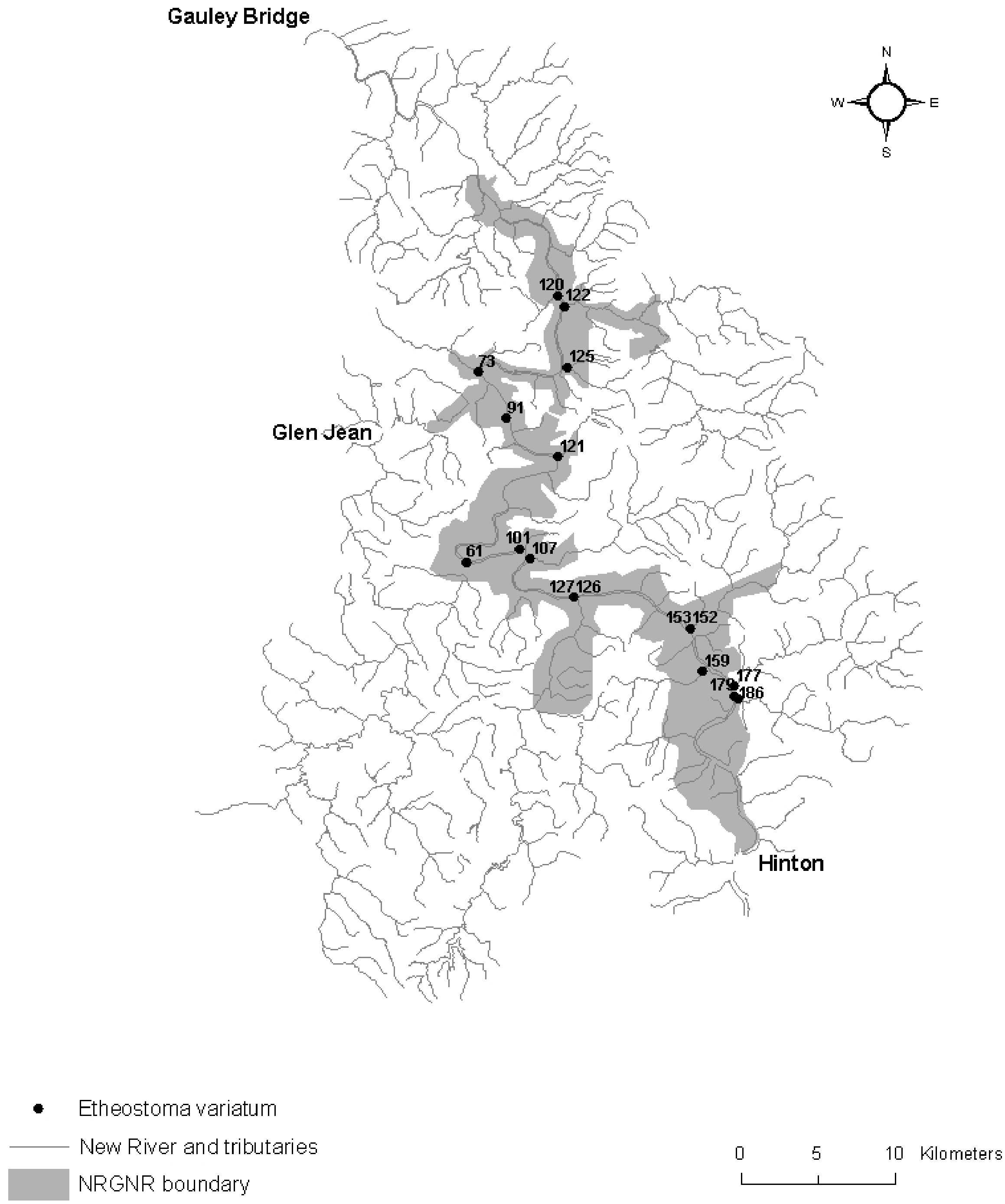

Figure 56. Collection sites for *Etheostoma variatum* (variegate darter) within and near the New River Gorge National River.

Percina caprodes (logperch)

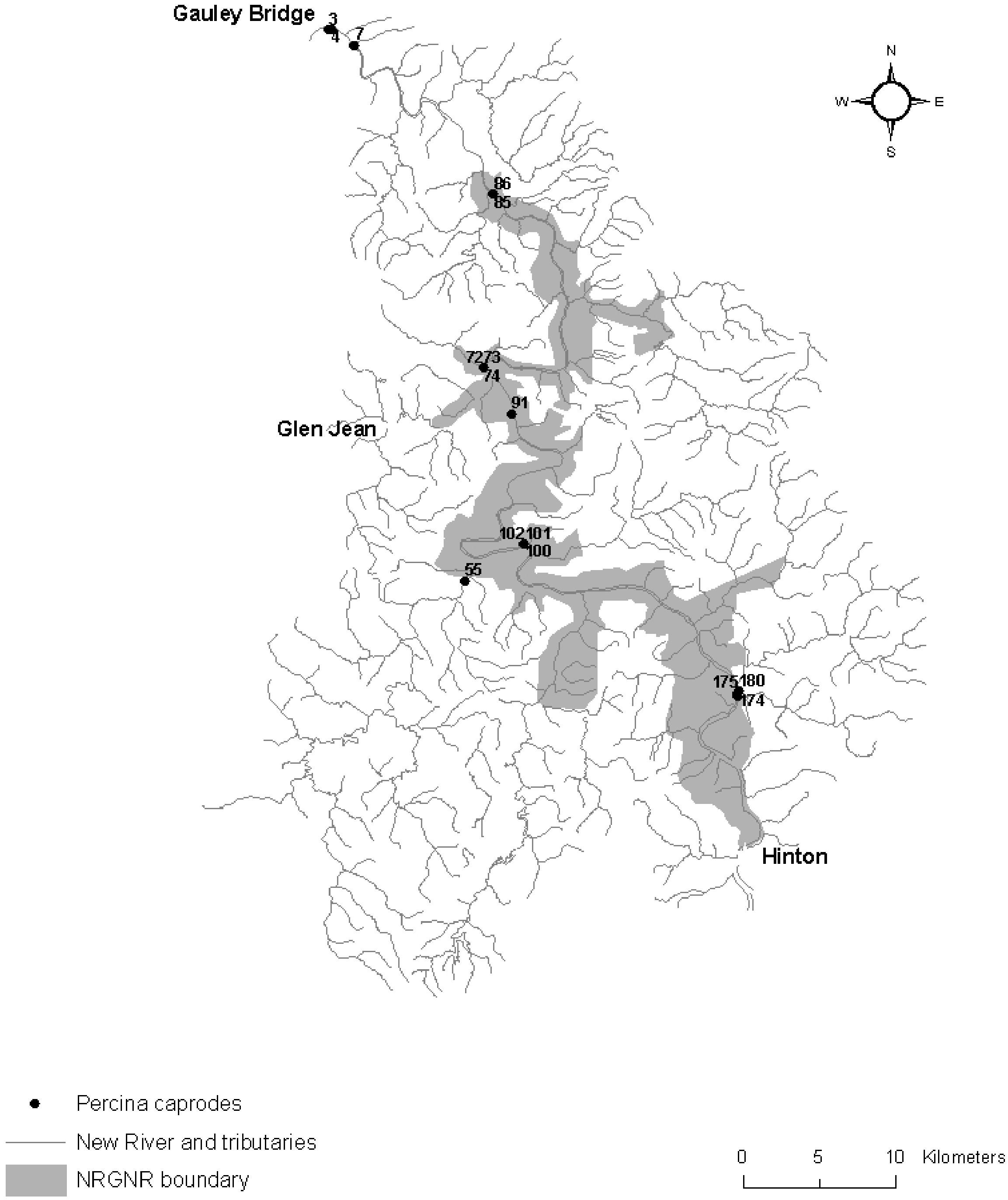

Figure 57. Collection sites for *Percina caprodes* (logperch) within and near the New River Gorge National River.

Percina maculata (blackside darter)

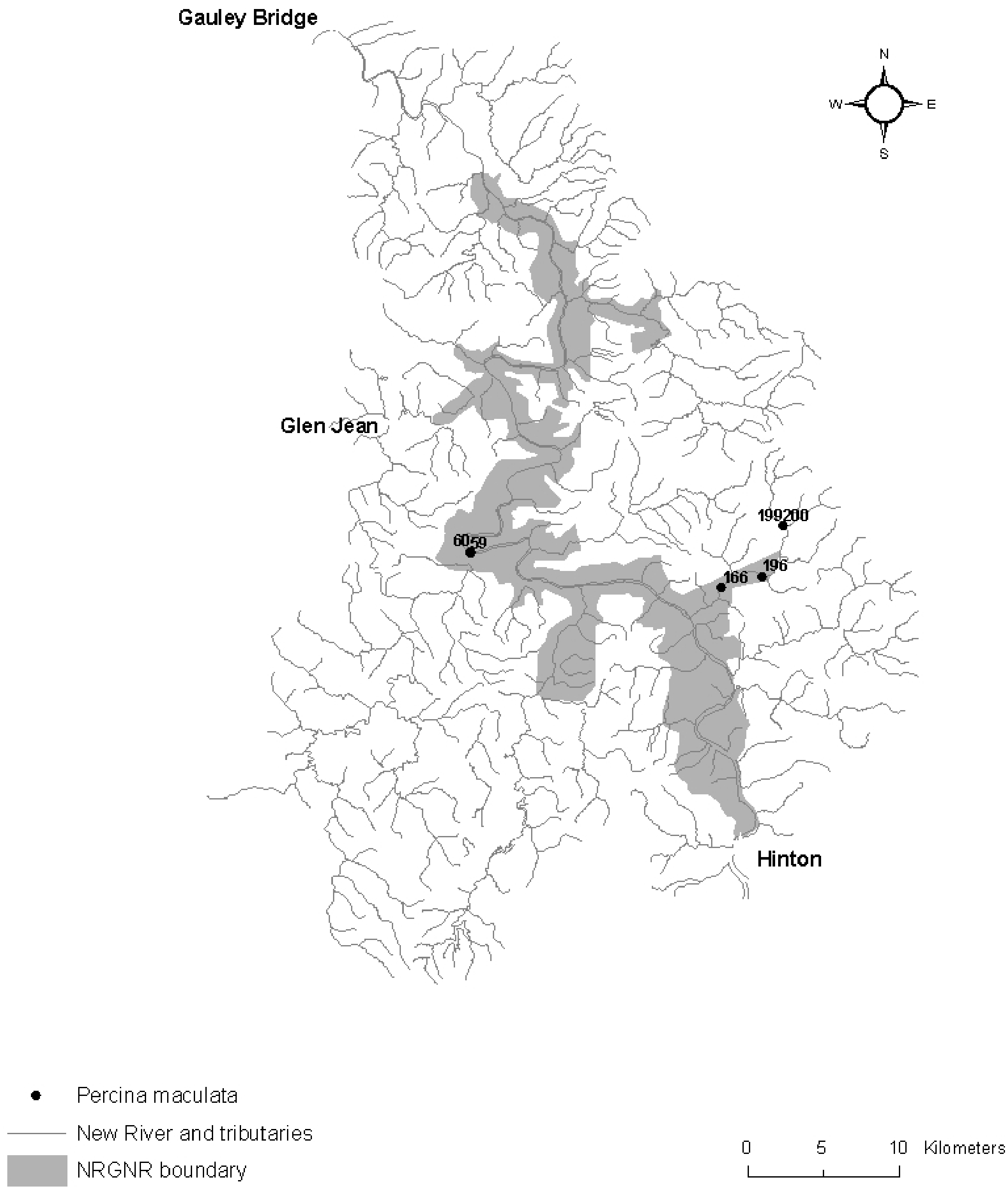

Figure 58. Collection sites for *Percina maculata* (blackside darter) within and near the New River Gorge National River.

Percina oxyrhynchus (sharpnose darter)

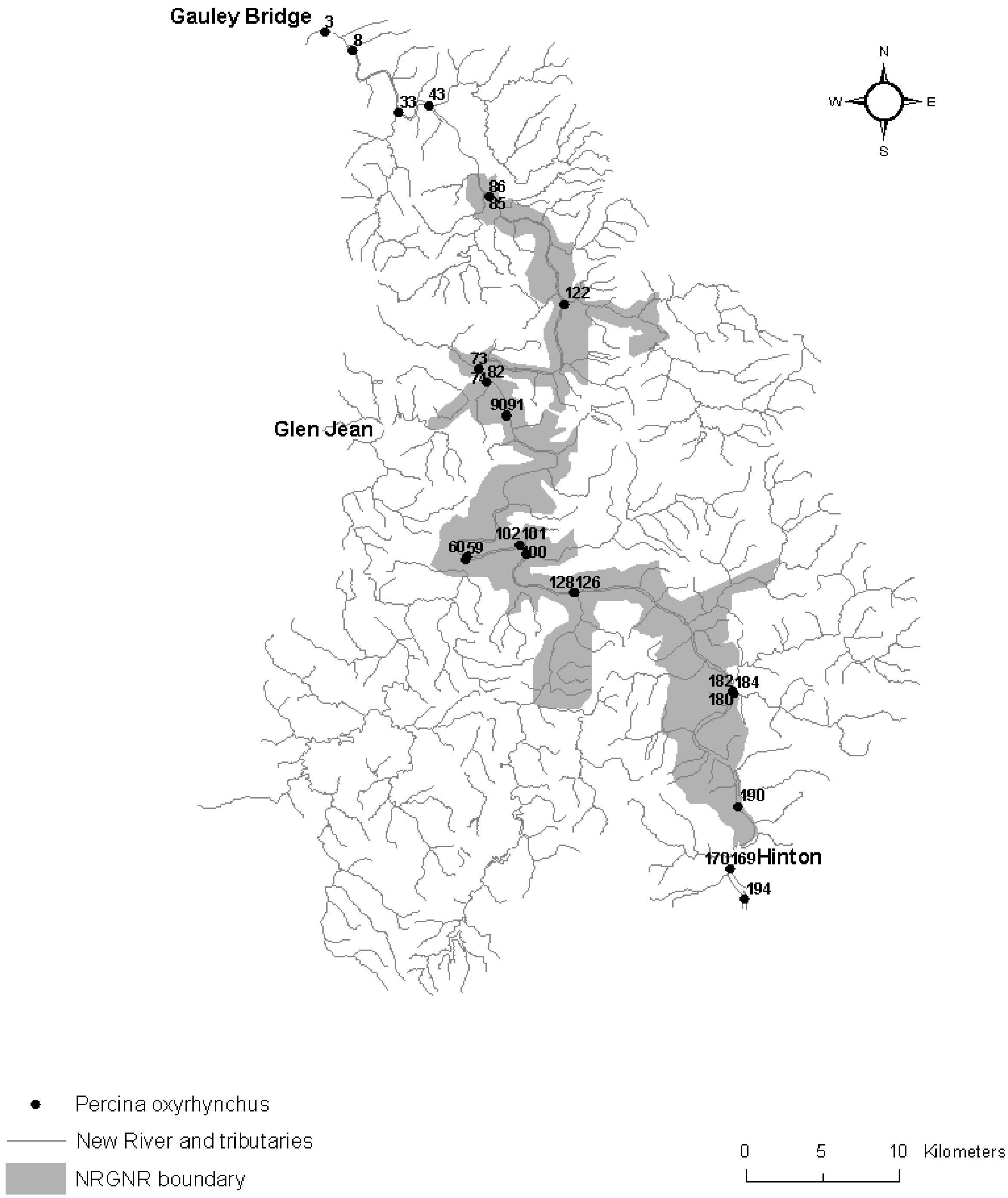

Figure 59. Collection sites for *Percina oxyrhynchus* (sharpnose darter) within and near the New River Gorge National River.

Percina roanoka (Roanoke darter)

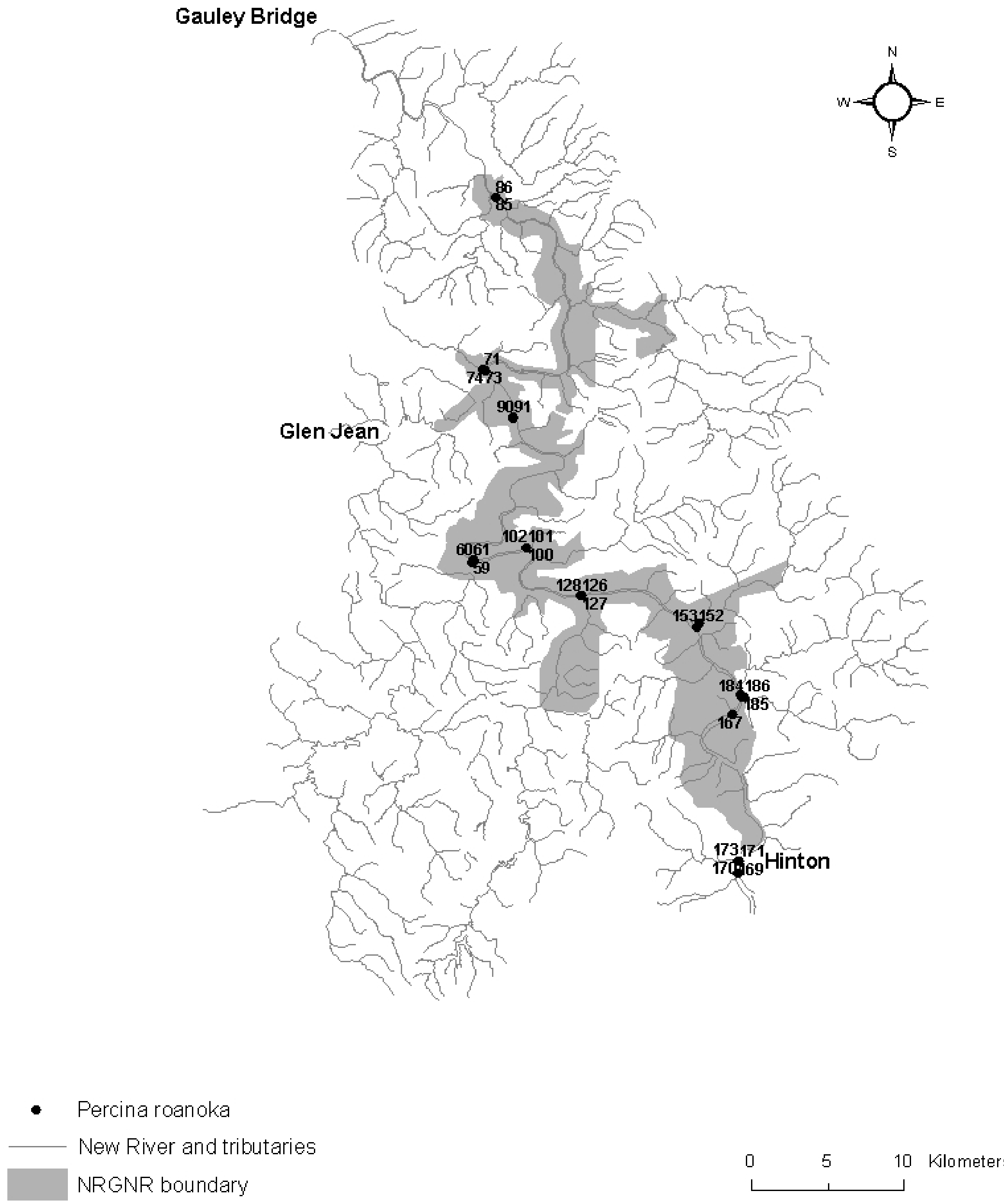

Figure 60. Collection sites for *Percina roanoka* (Roanoke darter) within and near the New River Gorge National River.

Perca flavescens (yellow perch)

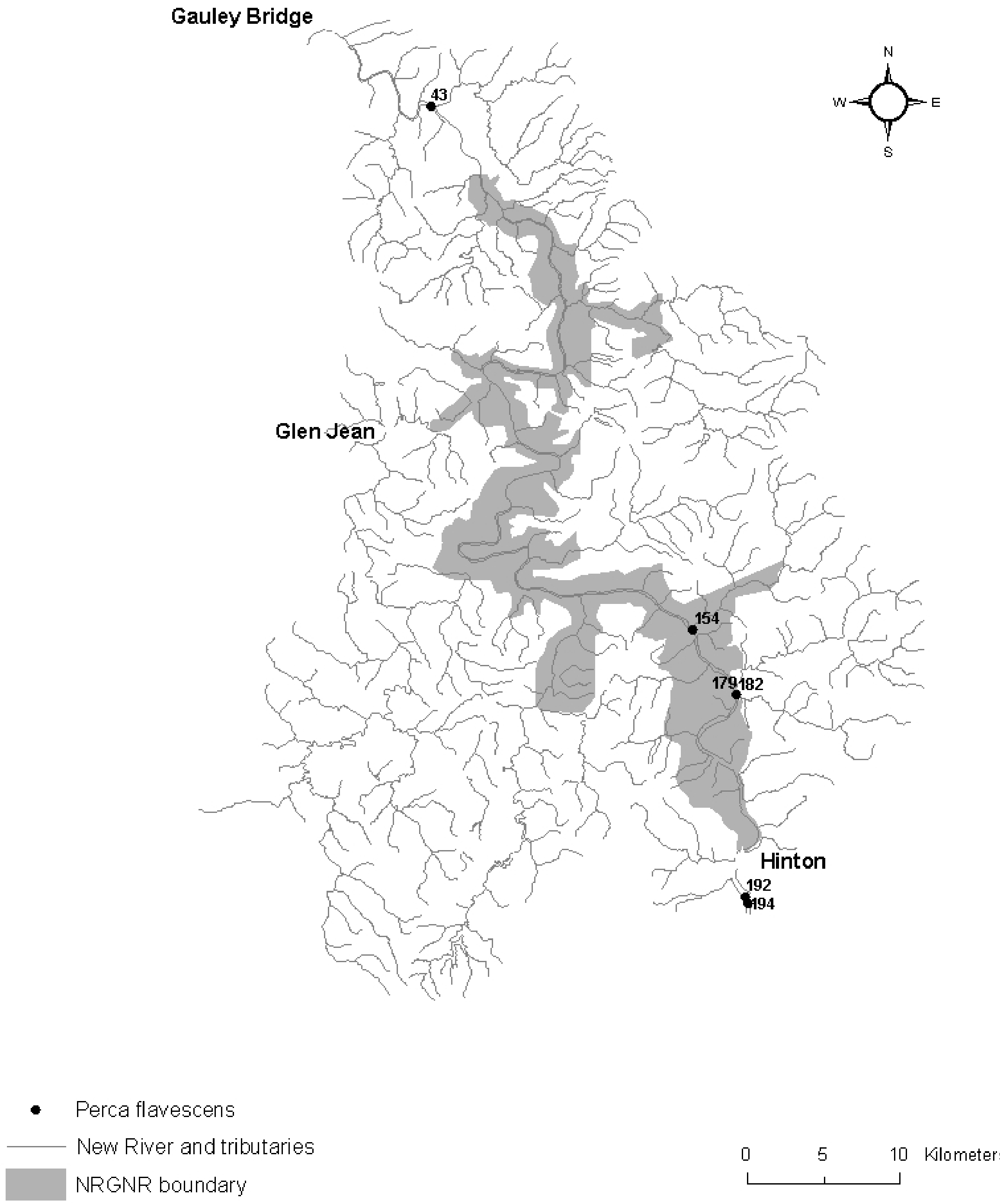

Figure 61. Collection sites for *Perca flavescens* (yellow perch) within and near the New River Gorge National River.

Sander vitreus (walleye)

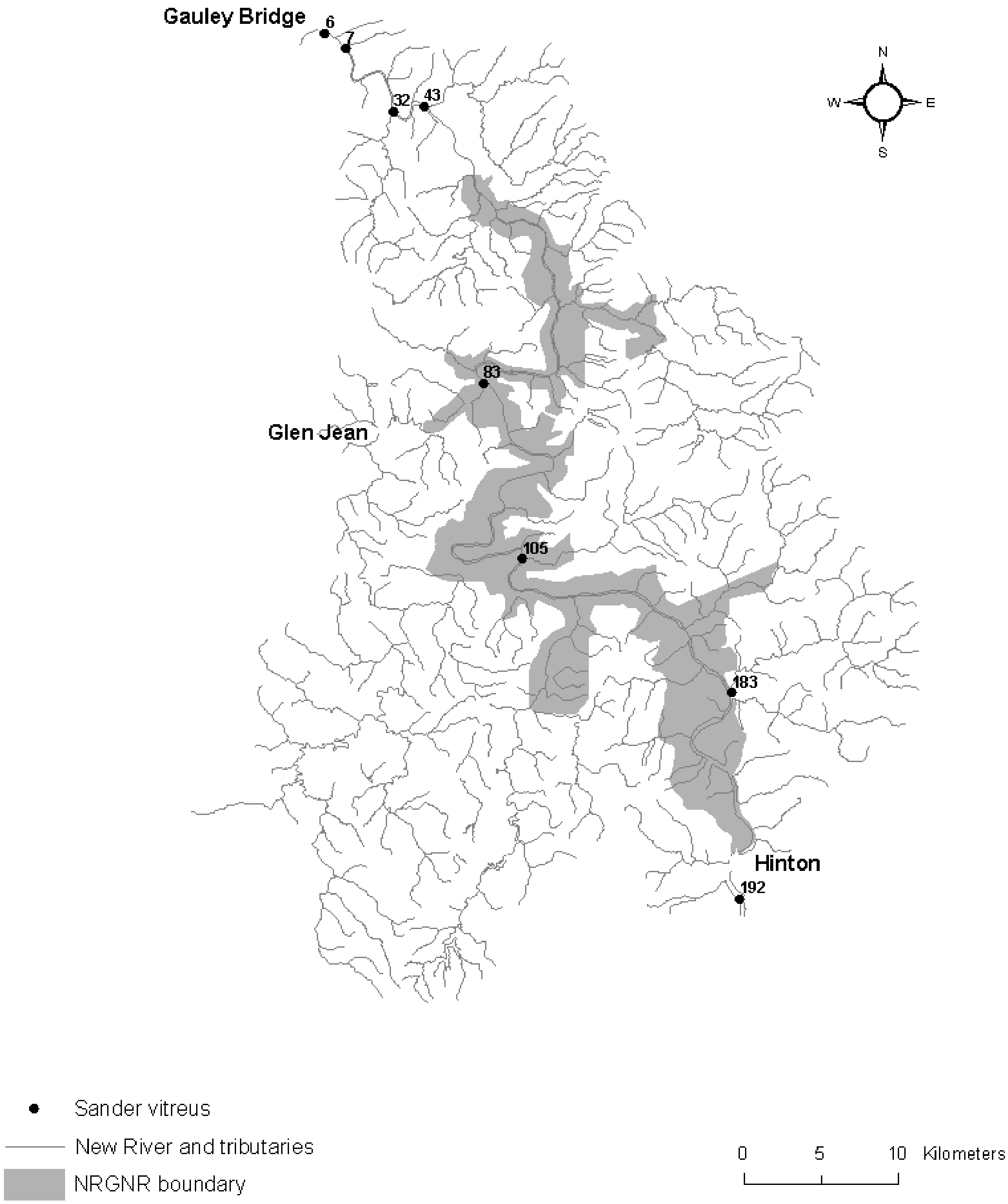

Figure 62. Collection sites for *Sander vitreus* (walleye) within and near the New River Gorge National River.

Scardinius erythrophthalmus (European rudd)

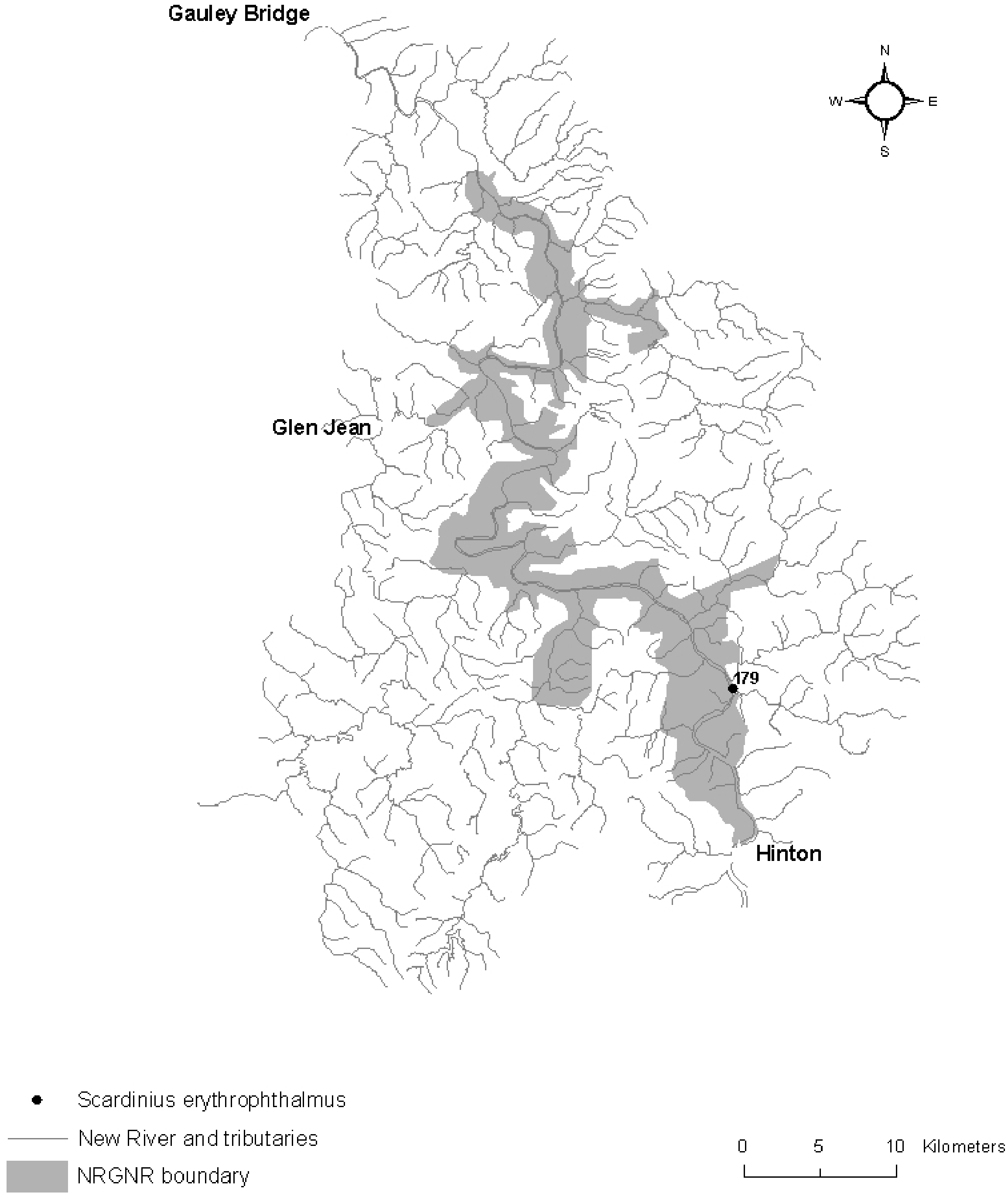

Figure 63. Collection sites for *Scardinius erythrophthalmus* (European rudd) within and near the New River Gorge National River.

Chapter 3: Post-flood Recolonization of Native and Nonnative Fishes in Tributaries within New River Gorge National River, West Virginia

ABSTRACT

Nonnative fishes represent an increasingly common biotic disturbance in lotic systems, and their interactions with native species are important to the conservation and management of fish communities. Biotic and abiotic disturbances synergistically influence fish communities in small unstable Appalachian streams, but interactions among multiple disturbances, such as nonnative species, floods, and droughts, are not well understood. The New River is a model system for the study of nonnative species; it contains the largest number and proportion of nonnative fishes in the eastern and central North American drainages (47 native and 45 nonnatives). In July 2001, flooding and debris flows within the lower section of the New River in New River Gorge National River (NRGNR) extirpated or reduced populations within small tributaries, and provided an opportunity to study recolonization and population recovery of native and nonnative fishes. Removal methods were used to estimate fish abundances at 12 tributary sites (nine flood impacted sites, and three reference sites) over a 20-month period (5 collection seasons). Although 29 species were observed (15 native and 14 nonnative), patterns of recolonization and population recovery were influenced primarily by four natives (stoneroller, blacknose dace, creek chub, and green sunfish) and four nonnatives (telescope shiner, whitetail shiner, smallmouth bass, and rainbow darter). Abundances of most species did not increase monotonically over the study period, but fluctuated among seasons. Abundances of nonnative fishes were generally less stable than those of natives across the study period. Seasonal variation in abundances among species was attributed to historic ecological factors, summer drought, immigration and emigration associated with seasonal habitat shifts, and juvenile recruitment.

INTRODUCTION

In lotic systems, synergistic effects of biotic and abiotic disturbances on fish abundances are not widely understood, but are important within a conservation framework of managing native fish communities (Cairns et al. 1971, Hughes et al. 1990, Reice et al. 1990, Detenbeck et al. 1992). The New River drainage provides a model system for addressing effects of biotic and abiotic disturbances on fish communities. In small tributaries of the New River system, introductions of nonnative fishes represent biotic disturbances, whereas floods and droughts are common abiotic disturbances.

The New River contains the largest number and proportion of nonnative fishes in the eastern and central North American drainages (47 native and 45 nonnative; Jenkins and Burkhead 1994, see Chapter 2). Eight of the 47 native species are endemic to the New River system, and thus possess conservational importance relative to potential negative impacts of nonnative fishes. Nonnative species may compete with natives in the New River system and the extent of possible negative impacts from competition is difficult to determine in observational field studies. Many factors dictate success of introduced fishes; system complexity, number of and abundance of native species, reproductive success of introduced species, size selection of predators on native and nonnative fishes, and competitive nature of native and introduced species (Ross 1991, Moyle and Light 1996). Nonnative species have many negative impacts on native species, such as habitat or trophic alterations, disease/parasite introductions, or hybridization (Ross 1991).

On the 8th and 26th of July 2001, flood waters and debris flows reduced or extirpated populations of native and nonnative fishes in several small tributaries of the New River, WV, within New River Gorge National River (NRGNR). Rain fall ranged from 76-140 mm and 51-

102 mm within 3 – 6 hour periods on July 8th and 26th respectively (NOAA 2003). Flood waters and debris flows restructured stream channels, scoured streambeds, removed riparian vegetation, and created large alluvial fans at tributary mouths. In contrast, West Virginia ranked 5th among states in August 2002 drought conditions (NOAA 2003). Consequently, many tributaries within NRGNR were dewatered or reduced to scattered pools during summer 2002. These flood and drought events reduced or extirpated fish populations in lower reaches of small tributaries of NRGNR (personal observation).

Reice et al. (1990) emphasized a need to define the role of disturbance in frequently disturbed systems, and to observe recovery of fish populations following disturbances so that fisheries resources can be effectively managed (Cairns et al. 1971, Hughes et al. 1990, Detenbeck et al. 1992). Abundance data are useful when examining fish recovery following disturbances (Ensign et al. 1997). It is difficult to assess biotic disturbances caused by nonnative fishes because introduction events occur at different time periods. This study, however, is unique because extensive flood waters removed native and nonnative fishes from small tributaries within New River Gorge, and allowed direct assessment of recolonization and abundances of native and nonnative fishes during a 20-month (5 sampling occasions) post-flood time series. Study objectives were to estimate seasonal abundances of native and nonnative fishes in small tributaries of NRGNR over 20 months following the July 2001 floods, and to examine among-season stability in abundances of native and nonnative fishes over this same period.

METHODS

Study area

The study was conducted within the boundaries of the NRGNR in southern West Virginia (Figure 1). The New River mainstem within NRGNR descends steeply through a deep gorge. River elevation ranges from about 427 m at the upstream end to about 244 m at the downstream end. The gorge rim rises typically 305 m above the New River with a maximum height of 488 m (Swift 2000). Smaller tributaries within NRGNR are extremely high gradient along the flanks of the gorge, and typically have three distinct sections; a mouth in the New River with a flood plain of low to moderate gradient, a steep descending section with cascades and water falls, and an upper plateau section with relatively low gradient. This study involved the lower, New River flood plain sections of 12 tributaries within NRGNR (Figure 2). Study streams were 1st to 3rd order with watersheds of 417 – 4,365 hectares. In the downstream reaches of NRGNR, floods and debris flows in the nine flood-impacted streams, restructured channels, removed riparian vegetation, and created large alluvial fans at tributary mouths. These factors were relatively unchanged in three reference streams in the upstream reaches of NRGNR.

Habitat data

Stream width, substrate size, and stream gradient were measured to document similarities in the physical characteristics of study reaches. Wetted width, bankfull width and substrate size at eleven equi-distant transects along each stream reach were measured to obtain mean values for each category (USEPA 1997). Substrate size was estimated at four equally spaced points and the thalweg along each transect (USEPA 1997). Channel gradients of study sites were estimated with a hand level and stadia rod.

Fish Collections

Fishes were collected from lower reaches of the study streams with backpack electrofishing unit during five seasons (fall 2001, spring, summer, and fall 2002, and spring 2003). At each site and season, fishes were collected with two or three passes through a stream reach, except for single passes in fall 2001. Only one pass was conducted during the first sampling season (approximately two months post-flood), because low abundances at this time prevented statistical estimation of population size. Stream reaches (with lowest point at the stream mouth) were approximately 40 times the mean wetted width with a minimum of 150 meters, except for streams with short flood plain sections. Due to narrow stream widths, backpack electrofishers efficiently captured fishes within the full width of the stream. For each pass, fishes were identified, measured (total length, TL) and counted. Fishes were released back into the sample reach following final pass of data collection.

Statistical analysis

For each stream site and season (except fall 2001), abundances of native and nonnative species were estimated with two or three-pass removal data (Program MARK, White 1999). Three detection probability models were fit to each three-pass data set, and included a behavioral response model, a constant model, and a model with a group effect (native vs. nonnative). Two models were fit to two-pass removal data; a constant detection probability model and a model with group effect (native vs. nonnative). The second-order adjustment of Akaike's information criterion (AICc) was used to weight models, where model-averaged abundance estimates and unconditional standard errors were calculated to account for model selection uncertainty (Burnham and Anderson 2003). To obtain estimates of abundance and variance by species origin and site category (i.e., natives at flood-impacted sites, nonnatives at flood-impacted sites, natives at reference sites, and nonnatives at reference sites), estimators were summed across sites (Mood et al. 1974; Thompson et al. 1998). A three-way analysis of variance (ANOVA; PROC GLM, SAS 1990) examined the following null hypotheses: 1) equal abundances between groups (native vs. nonnative), equal abundances among seasons, and equal abundances between sites (reference vs. flood-impacted). Significance level (α) was equal to 0.05.

As a measure of temporal stability, coefficients of variation (CV) for total abundances of species across five seasons were estimated. For this approach, among-season variation in abundances was considered as a measure of stability, where a CV of zero represents no among-season variation or the highest level of stability. The estimates of CV were aligned along an axis of stability for comparison among species with highest abundances, origin (native/nonnative), and site categories (flood-impacted/reference). The null hypotheses of no difference in CV values between groups of origin (native vs. nonnative) and between site categories (flood-impacted vs. reference) were tested with a two-way ANOVA (PROC GLM, SAS 1990; $\alpha = 0.05$).

RESULTS

Habitat

Mean wetted widths of study streams ranged from 2.0 to 5.6 m (Table 1). Stream substrates were generally gravel, cobble, and boulder and mean diameter of substrate size ranged from 54 mm to 360 mm (Table 1). Gradients for the three reference stream reaches ($\bar{x} = 2.5\%$) in the upper section of NRGNR were lower than those of flood-impacted streams ($\bar{x} = 7.4\%$). In general, streams with small watershed areas had highest gradients, and relatively short flood plain areas (which reduced the length of sample reach).

Fish

We collected 29 species and 5,813 individuals from the 12 study streams during five sampling seasons (Table 2). Native species (n=15) exceeded nonnatives (n=14); however, the total number of nonnative individuals (n=3,133) was higher than that of natives (n=2,680). Approximately 93% of nonnative fishes consisted of five species; telescope shiner *Notropis telescopus* (20.5%), whitetail shiner *Cyprinella galactura* (21%), smallmouth bass *Micropterus dolomieu* (17%), and rainbow darter *Etheostoma caeruleum* (31.5%; Table 2). About 95% of native fishes were comprised of four species; stoneroller *Campostoma anomalum* (57%), blacknose dace *Rhinichthys atratulus* (23%), creek chub *Semotilus atromaculatus* (9%), and green sunfish *Lepomis cyanellus* (6%; Table 2).

In all seasons, overall abundances of native and nonnative fishes in reference reaches exceeded those in flood-impacted reaches (Figure 3). Abundance estimates of native and non-native fishes (when combined by species across sites) followed a similar pattern of among-season variation (Figure 3), except for fall 2002 when non-native abundance (n=1,623) exceeded that of native fishes (n=978). Low estimates of native and non-native abundances during summer 2002 coincided with drought conditions (Figure 3). A significant difference between estimated abundances of native and nonnative fishes was not detected ($F = 0.06$, $df = 1$, $p = 0.82$). However, estimated abundances from reference sites were significantly greater than estimated abundances of flood-impacted sites ($F = 109.83$, $df = 1$, $p < 0.001$). Significant differences caused by seasonal effects on estimated abundances were also detected ($F = 31.02$, $df = 4$, $p = 0.003$).

The use of abundance estimates of native and non-native fishes (when combined by species across sites), however, obscured patterns of seasonal abundance among species. Based on total abundances for each species, variation in species abundances differed among seasons (Figure 4) and abundances of nonnative species were less stable than those of natives (Figure 5). Total abundances and CV values of the four most common native species were more stable than those of the four most common nonnatives across the 20-month study period (Figures 4 and 5). Stability of native fishes, as measured by CV values, significantly exceeded nonnative stability ($F = 5.82$; $df = 1$, $p = 0.033$). Stonerollers, blacknose dace, and creek chub maintained higher stabilities of among-season abundance, in part, due to the presence of juveniles and adults in all seasons (Appendix 1), and the ability to remain within study sites during summer drought conditions. Green sunfish maintained stable but low abundances over the study period, but a high number of juvenile immigrants during spring 2002 increased among-season instability estimates of reference sites.

Among-season variation in numbers of nonnative fishes exceeded that of native species (Figure 3); a pattern largely driven by high seasonal variation in abundances of adult whitetail and telescope shiners (Figures 4 and 5). The nonnative *Cyprinella galactura* was rarely collected during most seasons, except for fall 2002 when it was the most abundant (n=652) species (Figure 4). *Notropis telescopus* and *M. dolomieu* also reached highest abundances during fall seasons, and were relatively uncommon in tributaries during spring and summer seasons (Figure 4). *Etheostoma caeruleum,* the most abundant non-native fish (Table 2), was represented almost exclusively by adults (Appendix 1) and numbered highest during spring and lowest in summer and fall in both reference and flood-impacted sites (Figure 4).

DISCUSSION

The 20-month post-flood study period provided insights on recolonization and population recovery of native and nonnative fishes. Although 29 species were observed, patterns of recolonization and population recovery were influenced primarily by four natives (stoneroller, blacknose dace, creek chub, and green sunfish) and four nonnatives (telescope shiner, whitetail shiner, smallmouth bass, and rainbow darter). Most populations extirpated or reduced by July 2001 floods did not increase monotonically over the 20-month study period, but rather species abundances fluctuated among seasons. Abundances of nonnative fishes were generally less stable than those of natives across the 20-month time series. Seasonal variation in abundances among species was attributed to historic ecology, summer drought, immigration and emigration associated with seasonal habitat shifts, and juvenile recruitment.

High among-season variation in abundances of nonnative fishes may reflect historic ecological factors (John 1964, Ross et al. 1985, Matthews 1986, 1998). One of the dominant native species (green sunfish) and all of the dominant nonnatives (telescope shiner, whitetail shiner, smallmouth bass, and rainbow darter) are typical inhabitants of medium to large rivers within their native ranges; consequently, seasonal shifts to and from mainstem and tributary habitats may account for a large portion of seasonal variation in abundances. In contrast, three of the dominant natives (stoneroller, blacknose dace, and creek chub) are common inhabitants of small unstable Appalachian streams. Species in unstable streams are normally small, agile, early maturing, and rapid recolonizers with a wide range of physiological tolerances (Fausch and Bramblett 1991). Because floods have impacted fish communities throughout history, species in flood-prone areas lacking these characters have been selected against (Gorman and Karr 1978, Ross and Baker 1983, Moyle and Vondracek 1985). Biotic effects of floods should be minimal if fishes are adapted to frequent high discharges (Harrell 1978, Matthews 1998). Meffe and Minckley (1987) suggested stream fish assemblages are persistent in species presence, but vary in abundances following major disturbances.

Many stream reaches were reduced to small isolated pools within NRGNR during summer 2002 as West Virginia ranked fifth in the nation for August drought conditions (NOAA 2003). Overall, fish abundances decreased during summer 2002. Increased temperatures, decreased dissolved oxygen, and limited mobility are most likely responsible for the decline (Tramer 1977, Matthews 1998). Tolerance of high temperatures and low dissolved oxygen differ among species, and some fishes are able to survive in refuge pools during droughts (Capone and Kushlan 1991). Creek chub and green sunfish are common inhabitants of pools and their relatively stable seasonal abundances may reflect the importance of pool habitats in frequently disturbed areas such as the NRGNR. Tramer (1977) observed highest mortalities in fishes with subterminal mouths and no air bladders (i.e. darters) in refuge pools during summer months. During summer 2002, lower abundances of rainbow darter may have resulted from emigration during late spring, or mortality owing to summer drought conditions. In reference sites, blacknose dace and creek chub increased in abundance during summer 2002 due to higher numbers of juveniles, while stoneroller abundance decreased due to loss of adults. Higher overall abundances in reference sites during summer is partly explained by higher numbers of juveniles, but may also be related to cooler water temperatures of some tributaries that have more canopy cover than the New River mainstem. At flood-impacted sites, canopy cover decreased due to girdling or removal of trees by July 2001 floods. Therefore, lower abundances during summer 2002 may be indirectly related to elevated water temperatures, caused by flood-induced removal of riparian cover.

Immigration associated with habitat shifts and juvenile recruitment influenced seasonal fluctuations in abundances and differences among species in seasonal abundance. The native fishes with highest abundances or greater stabilities (stoneroller, blacknose dace, and creek chub) are common to small tributaries, whereas telescope and whitetail shiners prefer medium to large rivers in their native range. Telescope and whitetail shiners may use smaller tributaries as refuge habitat during fall. Additionally, juvenile smallmouth bass may have used smaller tributaries during fall to avoid predation. High abundances and stability of the three common native species (stoneroller, blacknose dace, and creek chub) were enhanced by the presence of juveniles and adults. Juveniles of native species could have resulted from reproduction within study sites or may represent immigrants from the New River mainstem. Based on expected spawning times (Jenkins and Burkhead 1994), however, juveniles of stoneroller, blacknose dace, and creek chub present in fall 2001 and spring 2002 were immigrants. High telescope and whitetail shiner abundances during fall in reference and flood-impacted reaches were primarily comprised of adults, except for the presence of juvenile whitetail shiners in reference sites during fall 2002. Because no whitetail shiners and few telescope shiners were collected during spring and summer in reference and flood-impacted sites, it is likely that adult and juvenile telescope and whitetail shiners represent immigrants from the mainstem New River.

CONCLUSION

Post-disturbance data on species abundances provide useful insight towards understanding fish recovery following disturbances. In this study, among-season variation in native and nonnative abundances during a 20-month post-flood period was associated with historic ecological factors, summer drought, immigration and emigration associated with seasonal habitat shifts, and juvenile recruitment. Seasonal abundance data supported stability of native fishes following sequences of major disturbances within small tributaries of the New River. In contrast, nonnative fish abundances were less stable among seasons in small tributaries. However, this may not imply that nonnative fish were less resilient than native species in the NRGNR. There was no statistical difference between native and nonnative fish abundances, though abundances at references sites exceeded those of flood-impacted sites. Also, abundances of nonnatives during fall exceeded those of other seasons; a pattern that likely reflects seasonal use of small tributaries by riverine species.

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Table 1. Study streams located within the New River Gorge National River (reference streams are asterisked). Slope estimates are for study reaches, not entire streams.

Stream Name	Watershed, hectares	Stream Order	Reach Length, m	Mean Wetted Width, m	Reach Slope %	Mean Substrate, mm
Brooks Branch *	454.0	1	156	2.8	1.7	97
Buffalo Creek	1,026.9	3	205	4.4	3.1	156
Coal Run	787.7	2	165	3.6	4.6	113
Ephriam Creek	1,382.2	3	184	3.7	2.2	135
Farley Creek *	1,731.4	2	222	3.3	2.2	144
Fern Creek	1,029.4	2	150	2.4	14.7	259
Fire Creek	417.0	1	162	-	7.6	-
Marr Branch	715.2	2	150	5.6	6.7	179
Mill Creek *	1,491.6	2	140	3.4	3.6	54
Short Creek	532.7	2	130	4.3	14.7	360
Slater Creek	812.2	1	151	2.0	3.4	71
Wolf Creek	4,364.9	3	210	5.3	7.0	164

Table 2. Total abundances of native (N = native, E = endemic, NI = native, but possibly introduced) and nonnative (I = introduced, IP = probably introduced) species from five sample periods. Origin categories are from Jenkins and Burkhead (1993).

Genus species	Common Name	Origin	Abundance
Cyprinidae			
Campostoma anomalum	central stoneroller	N	1513
Clinostomus funduloides	rosyside dace	N	7
Cyprinella galactura	whitetail shiner	IP	649
Cyprinella spiloptera	spotfin shiner	N	7
Luxilus albeolus	white shiner	NI	1
Nocomis platyrhinchus	bigmouth chub	E	45
Pimephales promelas	fathead minnow	I	1
Notropis hudsonius	spottail shiner	IP	20
Notropis telescopus	telescope shiner	IP	641
Notropis rubellus	rosyface shiner	N	25
Phoxinus oreas	mountain redbelly dace	N	10
Rhinicthys atratulus	blacknose dace	N	620
Rhinicthys cataractae	longnose dace	N	1
Semotilus atromaculatus	creek chub	N	249
Catostomidae			
Catostomus commersoni	white sucker	N	13
Hypentelium nigricans	northern hogsucker	N	18
Ictaluridae			
Ameiurus natalis	yellow bullhead	IP	1
Pylodictus olivaris	flathead catfish	N	1
Salmonidae			
Salvelinus fontinalis	brook trout	N	42
Salmo trutta	brown trout	I	16
Centrarchidae			
Ambloplites rupestris	rockbass	I	39
Lepomis cyanellus	green sunfish	N	164
Lepomis macrochirus	bluegill	I	54
Lepomis gibbosus	pumpkinseed	I	39
Micropterus dolomieu	smallmouth bass	I	537
Micropterus salmoides	largemouth bass	I	1
Percidae			
Etheostoma caeruleum	rainbow darter	I	979
Etheostoma variatum	variegate darter	I	102
Etheostoma blennioides	greenside darter	I	6

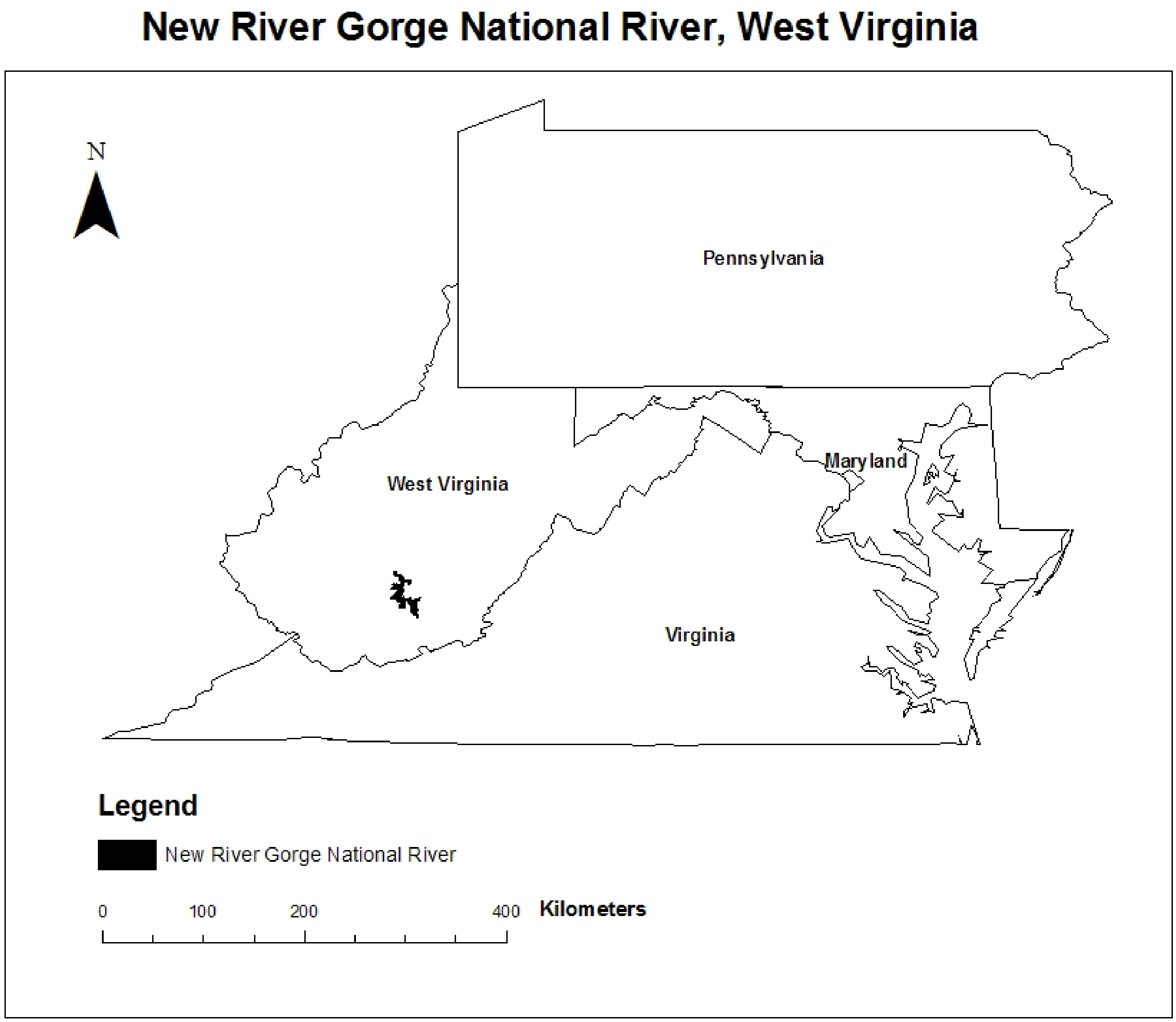


Figure 1. Location of New River Gorge National River in southern West Virginia.

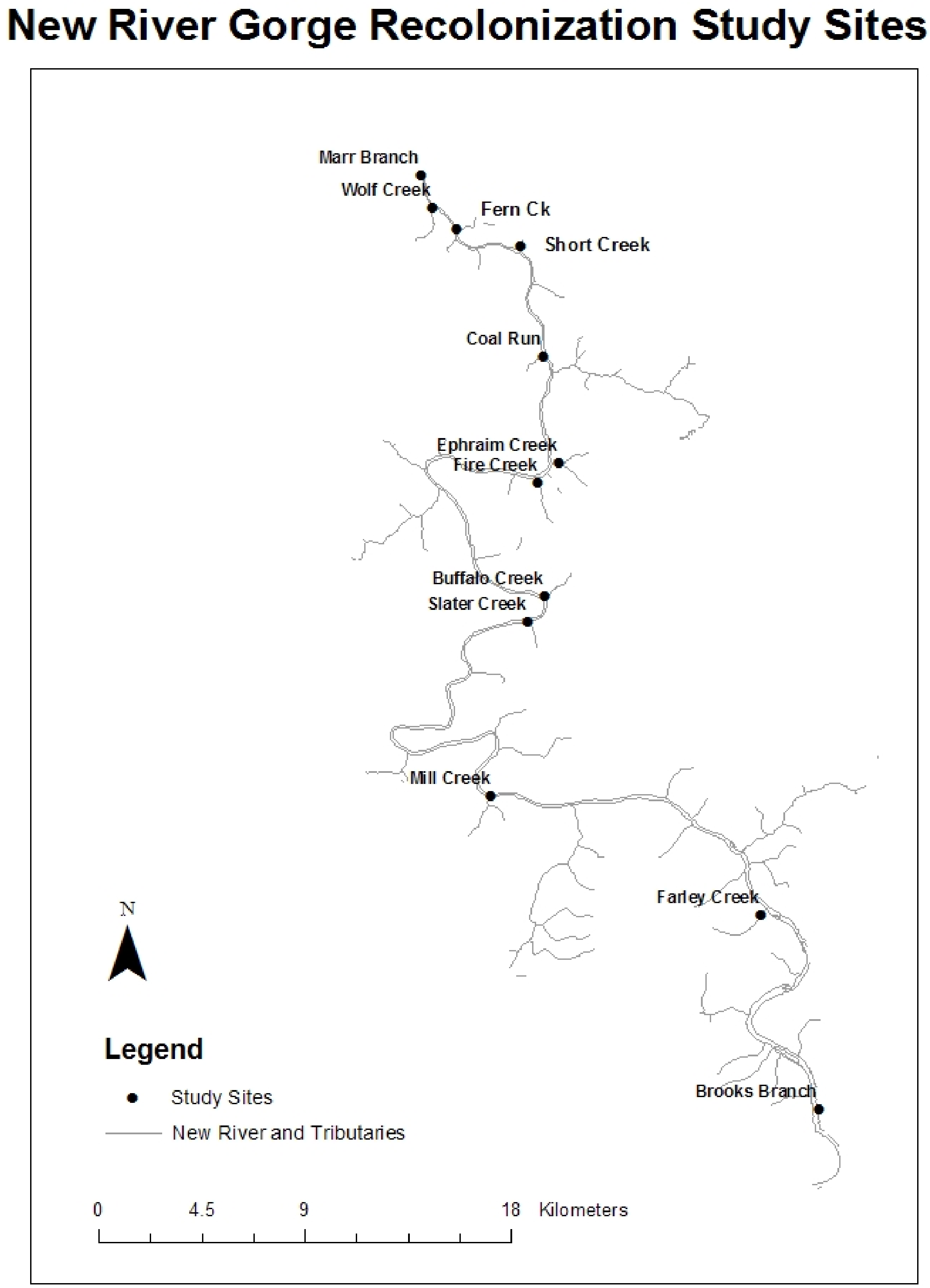


Figure 2. Location of twelve study sites in the New River Gorge National River.

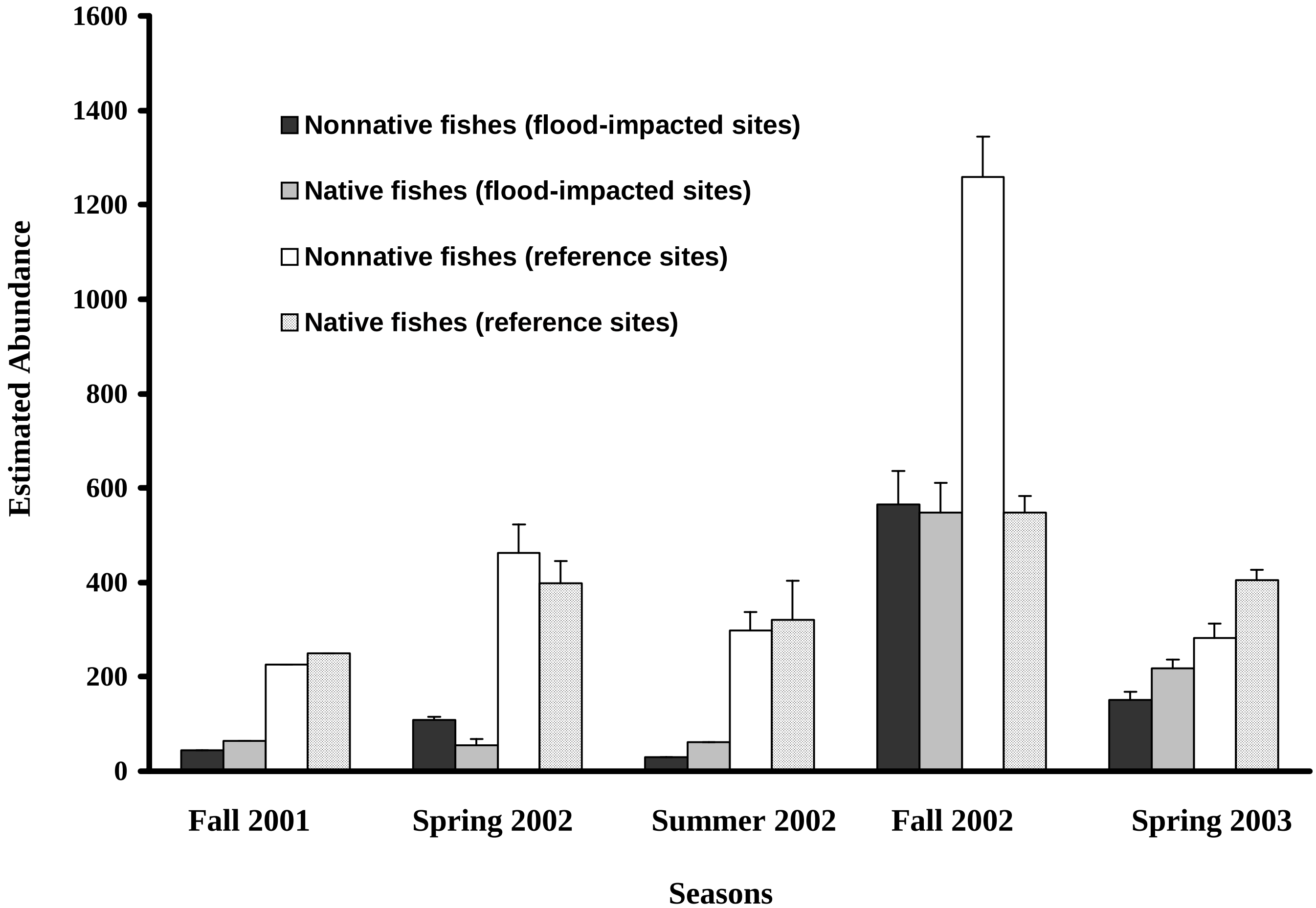


Figure 3. Estimated seasonal abundances of nonnative and native fishes in flood-impacted and reference reaches of tributaries in New River Gorge, West Virginia. Error bars represent upper 95% confidence intervals from two or three-pass removal estimates; precision was unestimable for single-pass abundance estimates during fall 2001 and flood-impacted sites during summer 2002.

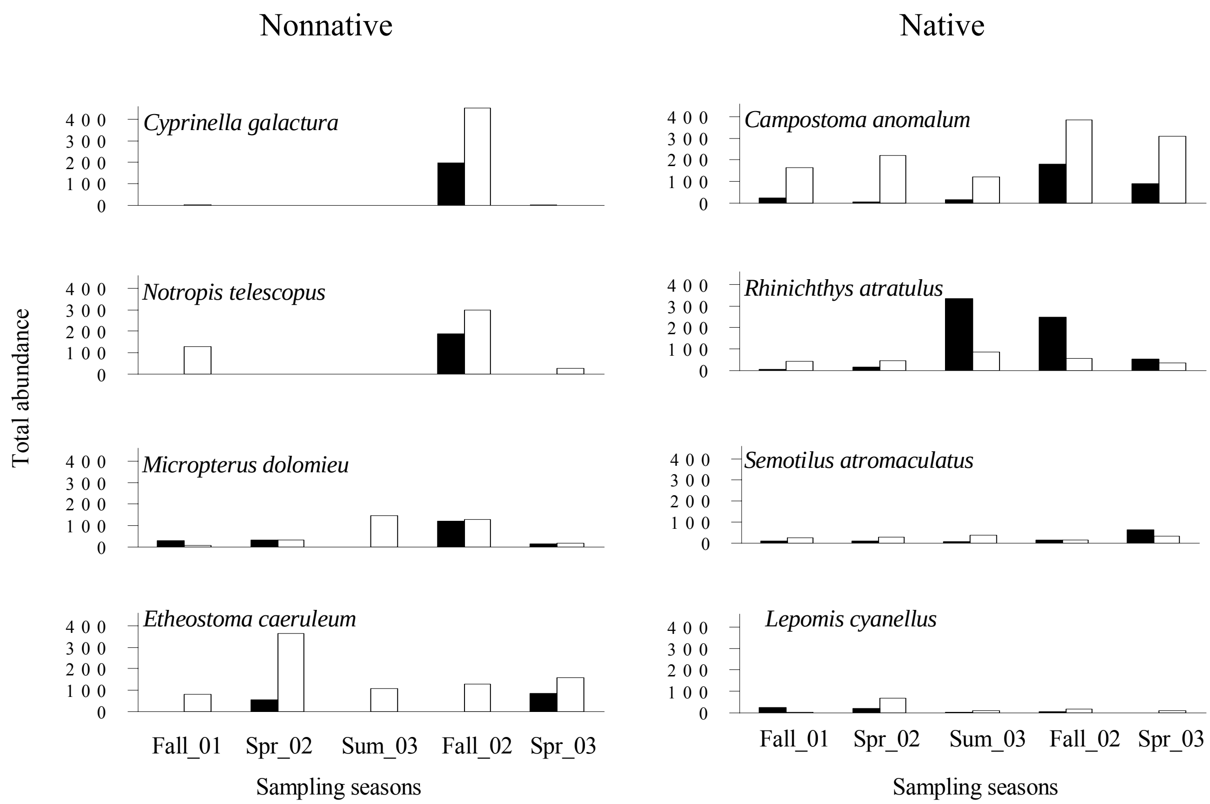


Figure 4. Abundances of dominant nonnative (first column) and native (second column) species in flood-impacted (closed bars) and reference (open bars) reaches of tributaries in New River Gorge, West Virginia, during five consecutive sampling seasons (fall 2001, spring 2002, summer 2002, fall 2002, and spring 2003).

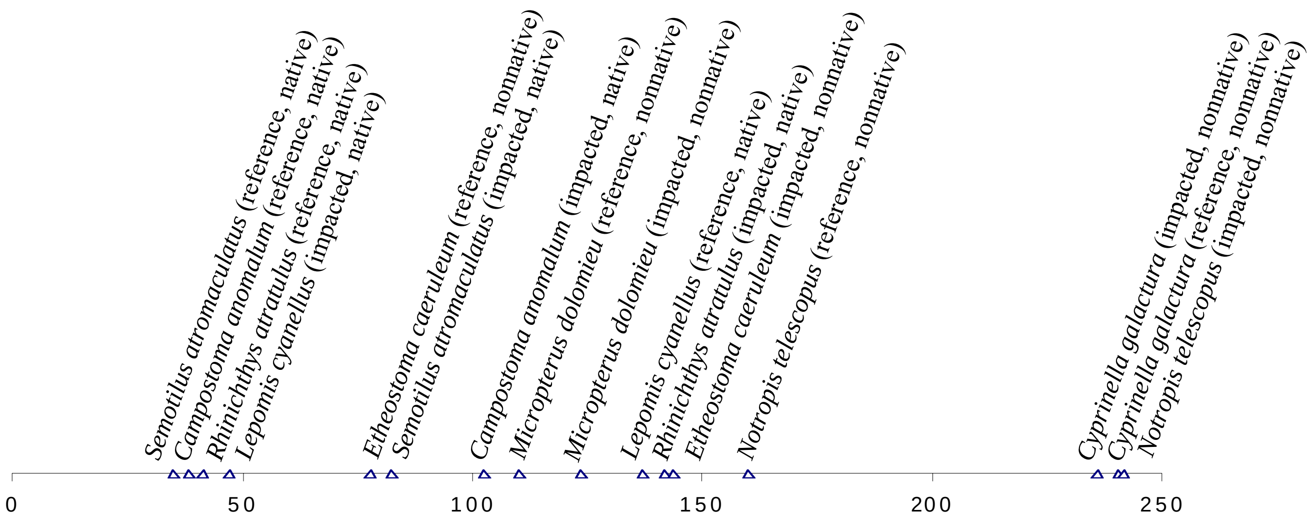
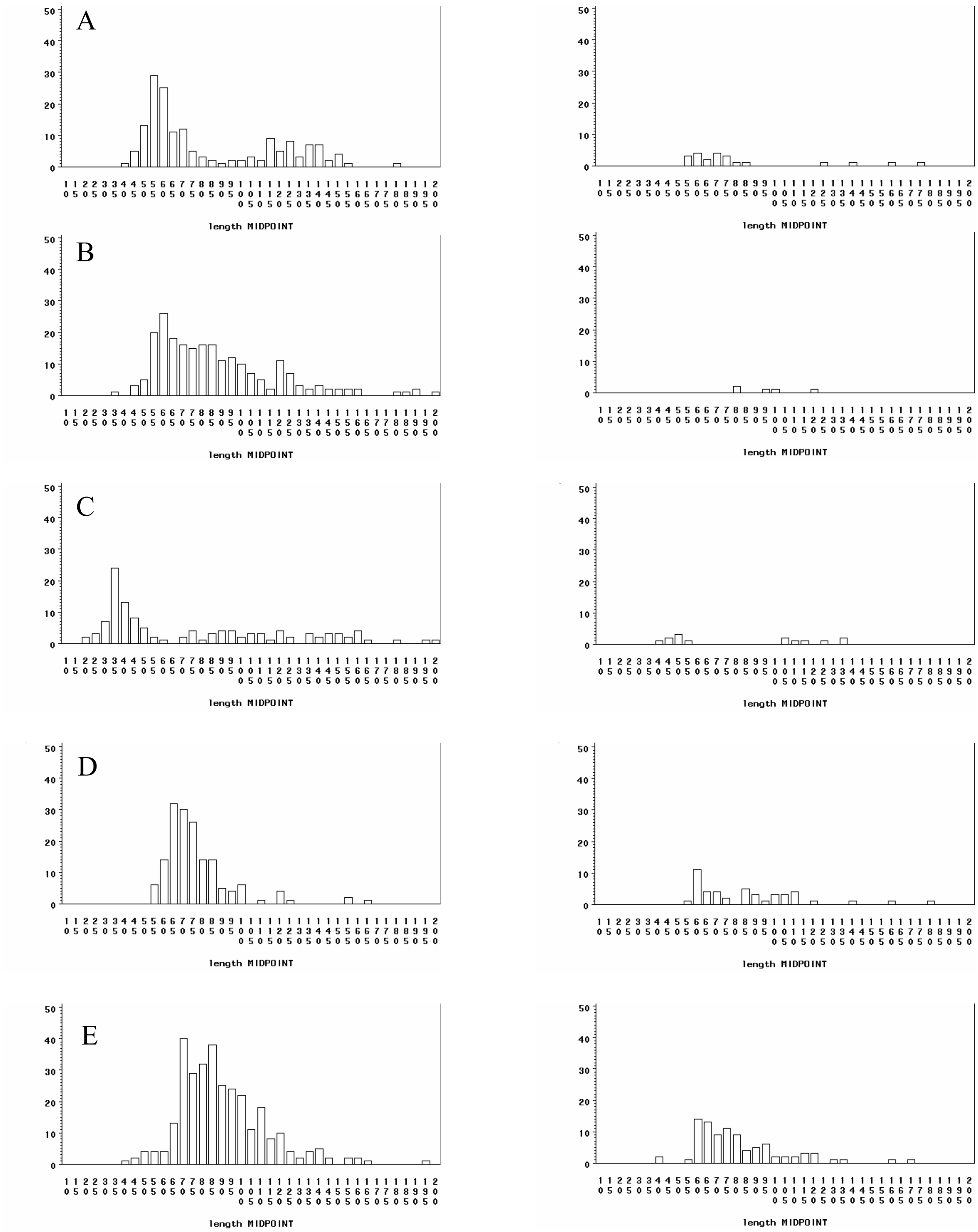
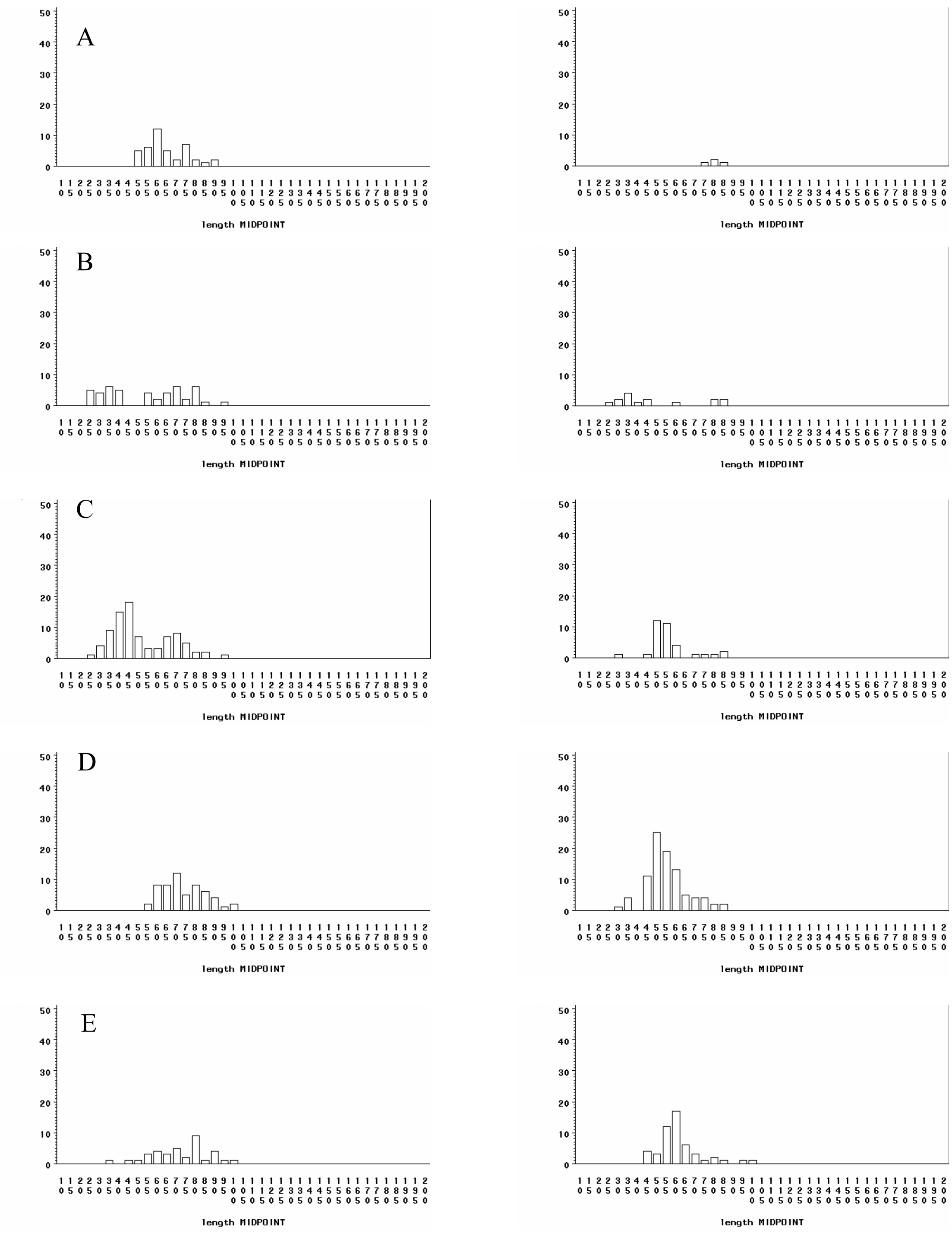


Figure 5. Coefficients of variation (CV; representing an axis of temporal stability) of among-season abundances of eight common species in tributaries within New River Gorge National River. A CV of zero represents no among-season variation or the highest level of stability.

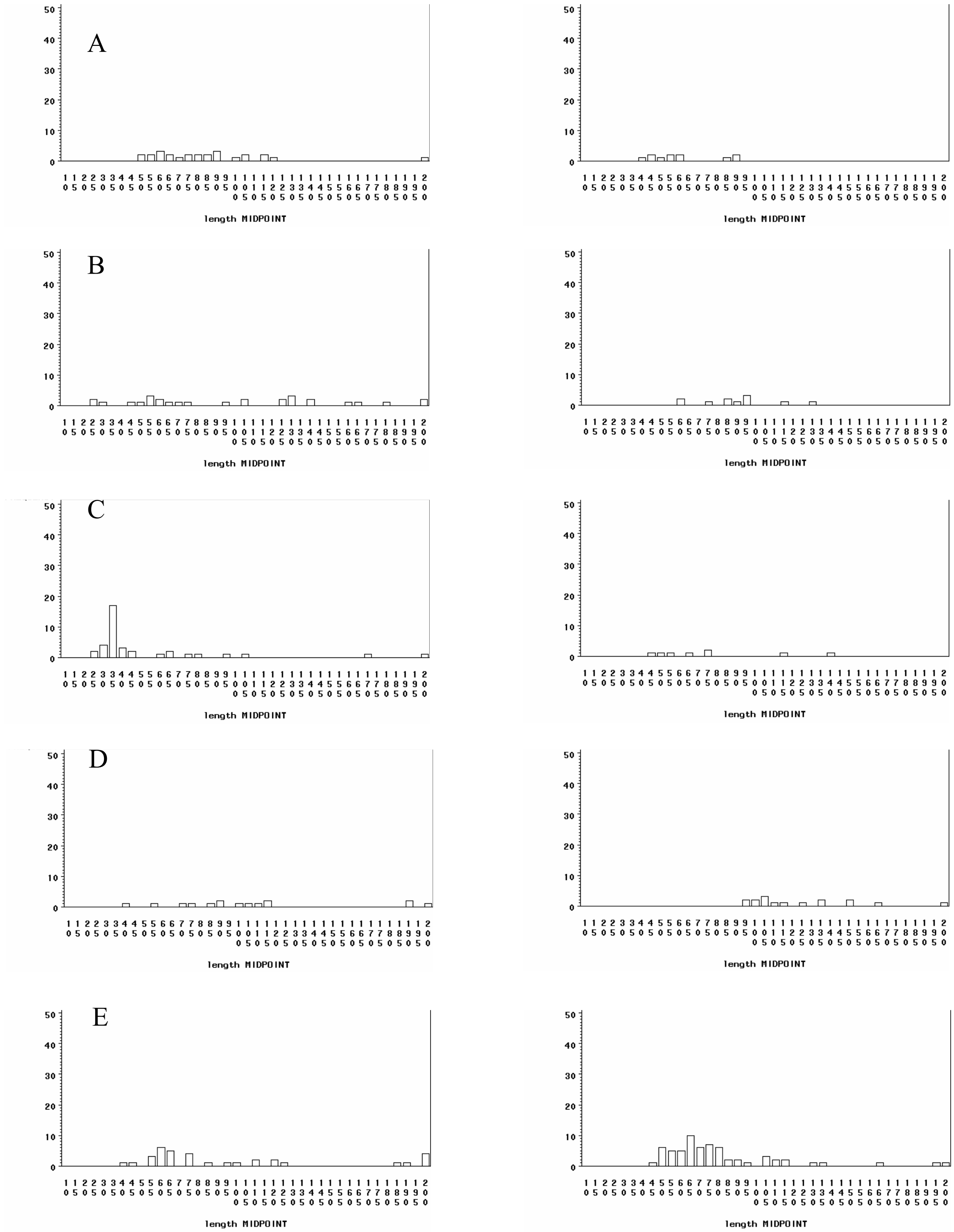
Appendix I



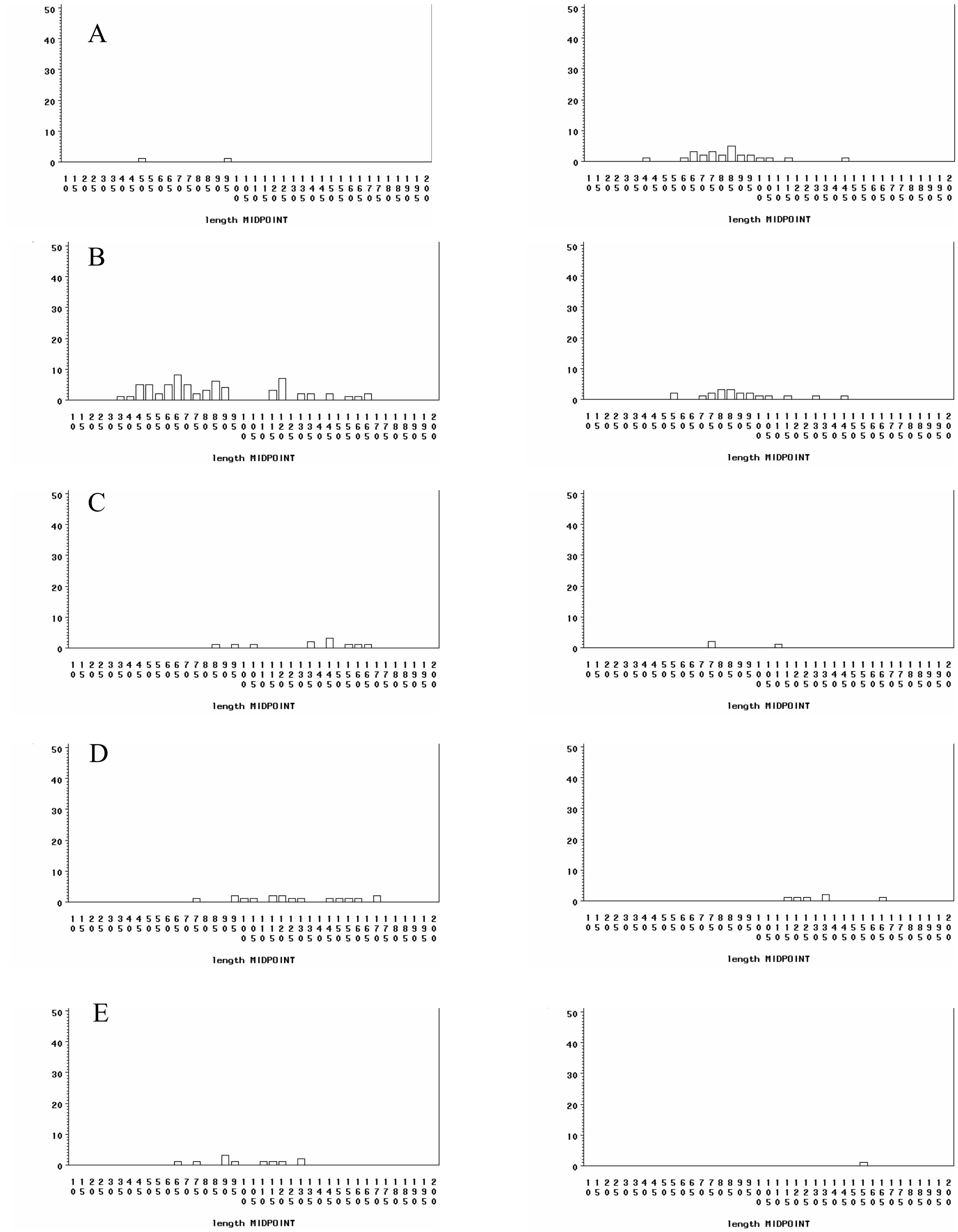
Appendix 1a. Length distributions (5 mm TL groups) of stonerollers from combined reference (left column) and flood-impacted (right column) sites separated by five seasonal sampling periods (A= fall 2001, B = spring 2002, C = summer 2002, D = fall 2002, and E = spring 2003). Adults are 60 - 150 mm SL (Jenkins and Burkhead 1994).



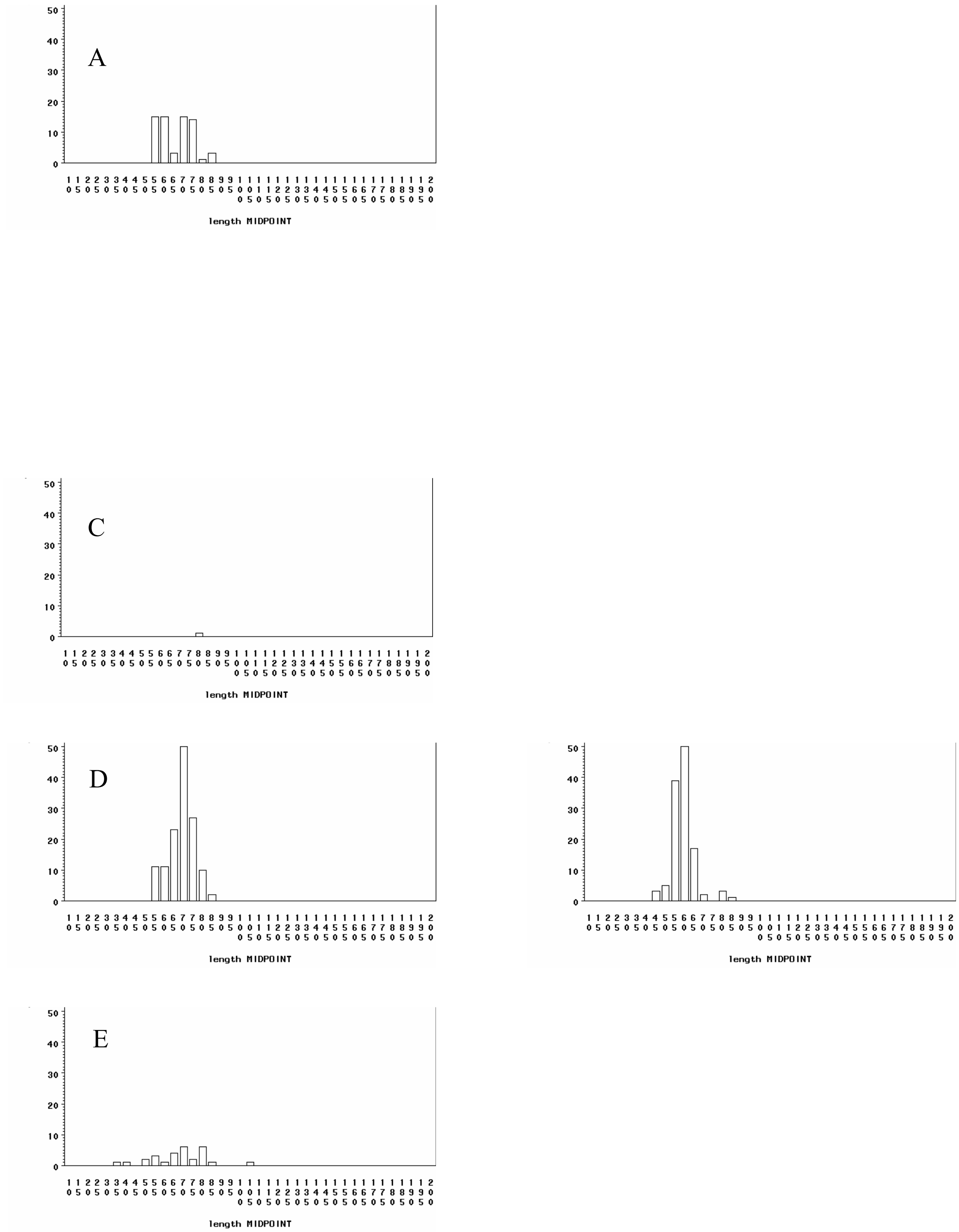
Appendix 1b. Length distributions (5 mm TL groups) of blacknose dace from combined reference (left column) and flood-impacted (right column) sites separated by five seasonal sampling periods (A= fall 2001, B = spring 2002, C = summer 2002, D = fall 2002, and E = spring 2003). Adults are 40 - 70 mm SL (Jenkins and Burkhead 1994).



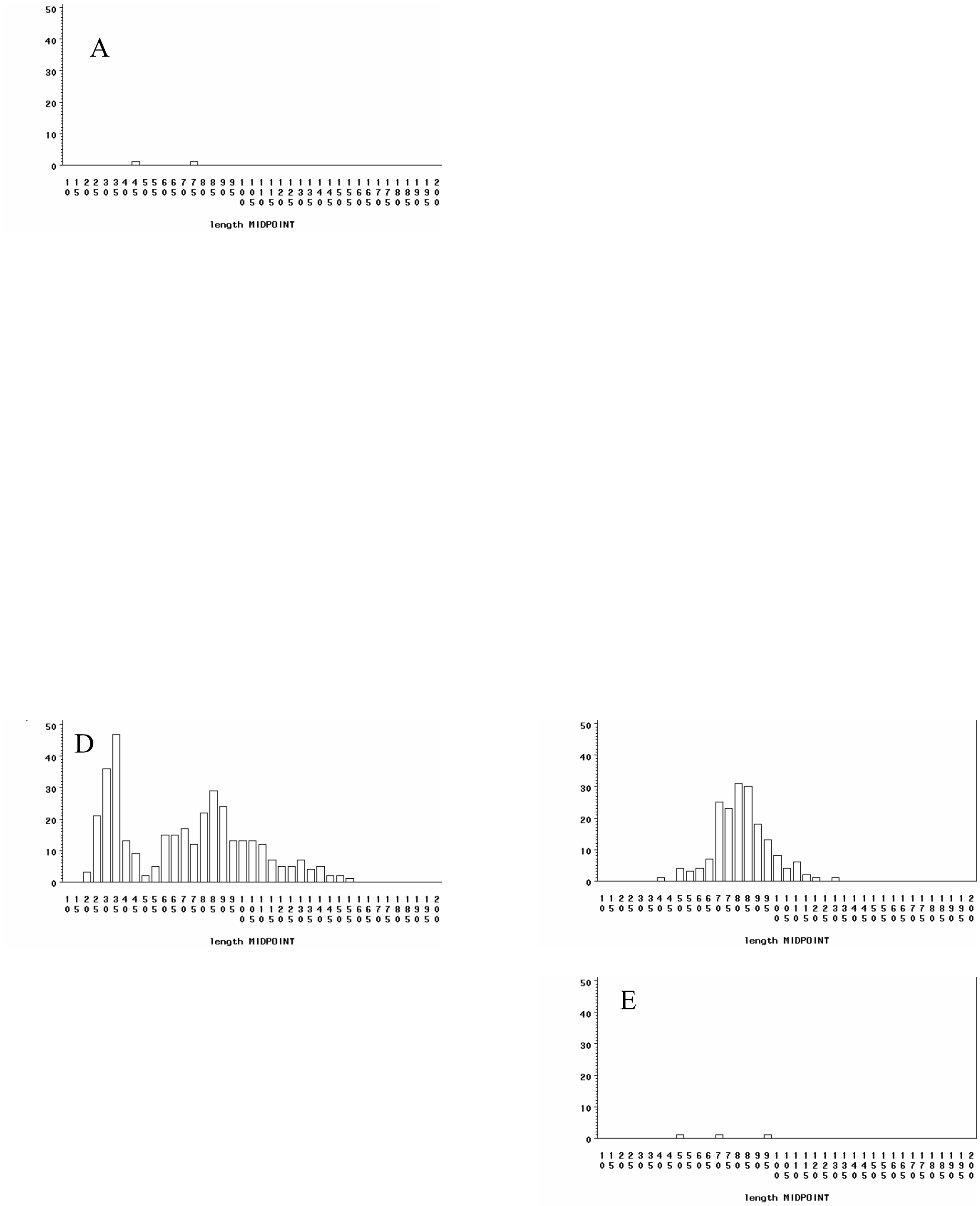
Appendix 1c. Length distributions (5 mm TL groups) of creek chubs from combined reference (left column) and flood-impacted (right column) sites separated by five seasonal sampling periods (A= fall 2001, B = spring 2002, C = summer 2002, D = fall 2002, and E = spring 2003). Adults are 80 - 200 mm TL (Jenkins and Burkhead 1994).



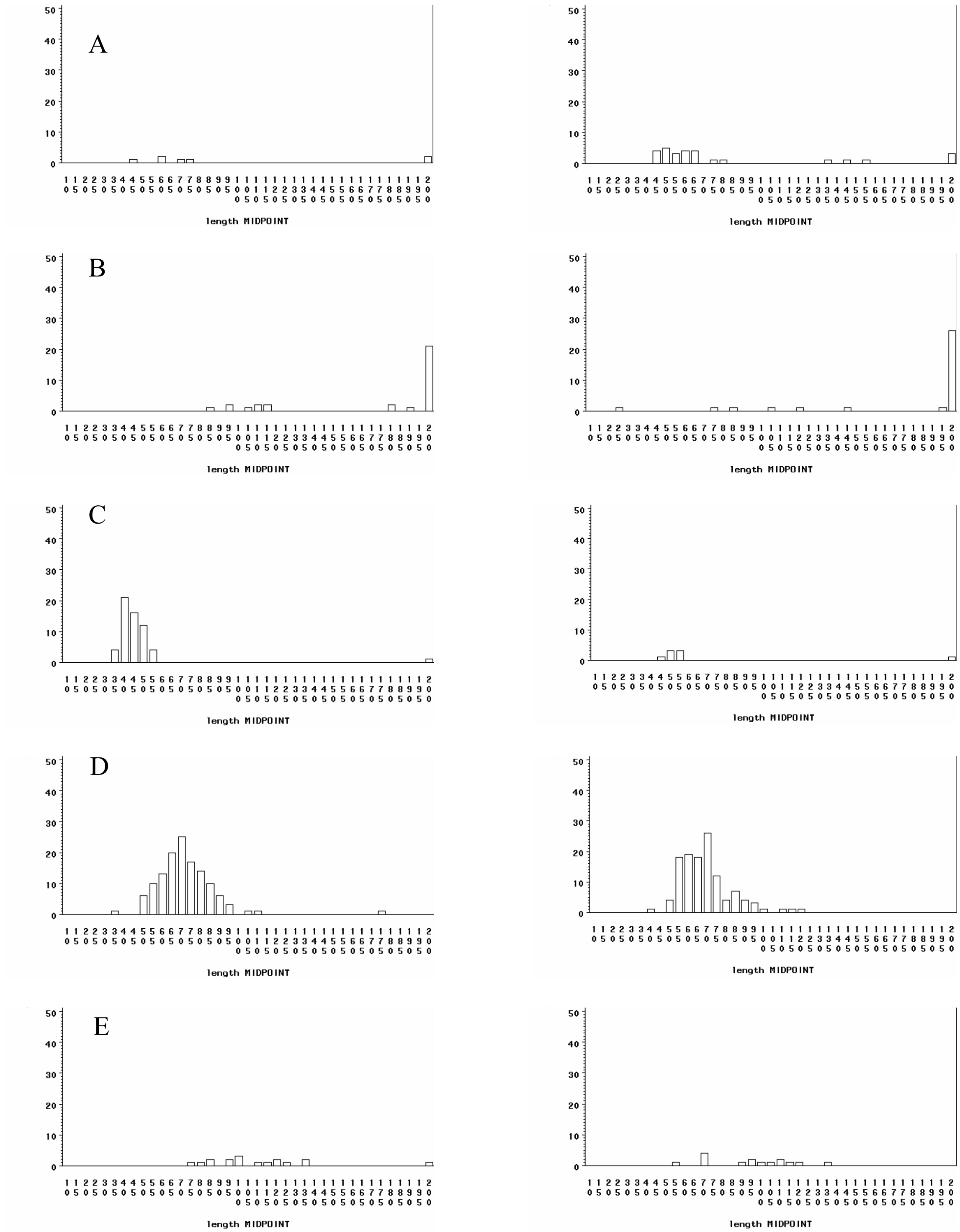
Appendix 1d . Length distributions (5 mm TL groups) of green sunfish from combined reference (left column) and flood-impacted (right column) sites separated by five seasonal sampling periods (A= fall 2001, B = spring 2002, C = summer 2002, D = fall 2002, and E = spring 2003). Adults are 70 - 180 mm TL (Jenkins and Burkhead 1994).



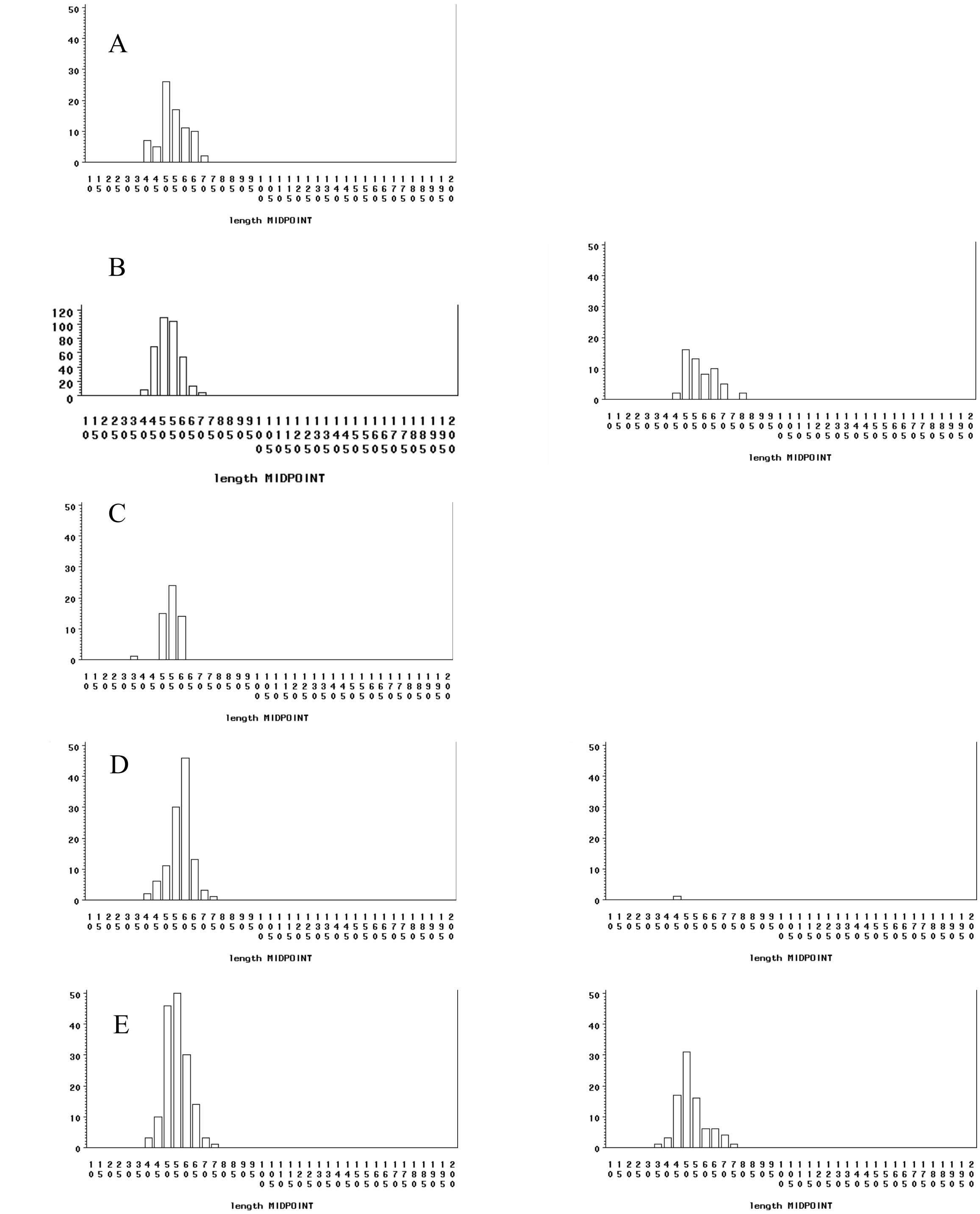
Appendix 1e. Length distributions (5 mm TL groups) of whitetail shiners from combined reference (left column) and flood-impacted (right column) sites separated by five seasonal sampling periods (A= fall 2001, B = spring 2002, C = summer 2002, D = fall 2002, and E = spring 2003). Adults are 50 - 100 mm SL (Jenkins and Burkhead 1994).



Appendix 1f. Length distributions (5 mm TL groups) of telescope shiners from combined reference (left column) and flood-impacted (right column) sites separated by five seasonal sampling periods (A= fall 2001, B = spring 2002, C = summer 2002, D = fall 2002, and E = spring 2003). Adults are 45 - 60 mm SL (Jenkins and Burkhead 1994).



Appendix 1g. Length distributions (5 mm TL groups) of smallmouth bass from combined reference (left column) and flood-impacted (right column) sites separated by five seasonal sampling periods (A= fall 2001, B = spring 2002, C = summer 2002, D = fall 2002, and E = spring 2003). Adults are 200 - 430 mm TL (Jenkins and Burkhead 1994).



Appendix 1h. Length distributions (5 mm TL groups) of rainbow darters from combined reference (left column) and flood-impacted (right column) sites separated by five seasonal sampling periods (A= fall 2001, B = spring 2002, C = summer 2002, D = fall 2002, and E = spring 2003). Adults are 35 - 50 mm SL (Jenkins and Burkhead 1994).

Appendix II

New River Gorge National River Fish Data

Brooks Branch

Species	Common Name	Seasons: Fall 2001	Spring 2002	Summer 2002	Fall 2002	Spring 2003	Total
Cyprinidae							
Campostoma anomalum	central stoneroller	85	173	78	185	219	740
Cyprinella galactura	whitetail shiner	2	0	0	237	0	239
Cyprinella spiloptera	spoffin shiner	0	0	0	7	0	7
Nocomis platyrhyncus	bigmouth chub	3	4	19	0	0	26
Notropis hudsonius	spottail shiner	0	0	0	0	18	18
Notropis rubellus	rosyface shiner	0	0	1	0	0	1
Notropis telescopus	telescope shiner	14	0	0	20	22	56
Phoxinus oreas	mountain redbelly dace	4	3	0	0	0	7
Rhinycthys atratulus	blacknose dace	6	0	25	1	0	32
Semotilus atromaculatus	creek chub	4	9	31	3	3	50
Catostomidae							
Catastomis commersoni	white sucker	0	0	2	0	0	2
Hypentilium nigricans	northern hogsucker	0	0	3	0	0	3
Ictaluridae							
Ameirus natalis	yellow bullhead	0	0	1	0	0	1
Centrachidae							
Ambloplites rupestris	rock bass	6	6	1	41	23	77
Lepomis cyanellus	green sunfish	2	44	1	0	4	51
Lepomis gibbosus	pumpkinseed	0	0	0	32	1	33
Lepomis macrochirus	bluegill	0	0	0	52	0	52
Micropterus dolomieu	smallmouth bass	1	3	247	64	15	330
Micropterus punctulatus	spotted bass	1	0	0	0	0	1
Percidae							
Etheostoma caeruleum	rainbow darter	39	208	4	10	37	298
	Total	167	450	413	652	342	2024

New River Gorge National River Fish Data

Buffalo Creek

		Seasons					
Species	**Common Name**	**Fall 2001**	**Spring 2002**	**Summer 2002**	**Fall 2002**	**Spring 2003**	**Total**
Cyprinidae							
Campostoma anomalum	central stoneroller	0	2	8	178	44	232
Nocomis platyrhynus	bigmouth chub	0	0	0	2	0	2
Rhinichthys atratulus	blacknose dace	0	0	9	2	0	11
Catostomidae							
Catostomus commersoni	white sucker	1	0	0	0	0	1
Hypentilium nigricans	northern hogsucker	0	0	0	1	0	1
Salmonidae							
Salmo trutta	brown trout	1	1	0	0	6	8
Salvelinus fontinalis	brook trout	6	2	13	7	2	30
Semotilus atromaculatus	creek chub	1	0	0	0	0	1
Centrarchida							
Ambloplites rupestris	rockbass	0	2	0	0	0	2
Micropterus dolomieu	smallmouth bass	11	4	3	25	4	47
Percidae							
Etheostoma blennioides	greenside darter	0	0	0	0	1	1
Etheostoma caeruleum	rainbow darter	0	36	0	1	64	101
Etheostoma variatum	variegate darter	1	1	0	0	9	11
	Total	21	48	33	216	130	448

New River Gorge National River Fish Data

Coal Run

Species	Common Name	Fall 2001	Spring 2002	Summer 2002	Fall 2002	Spring 2003	Total
		Seasons					
Cyprinidae							
Campostoma anomalum	central stoneroller	3	1	3	5	8	20
Cyprinella galactura	whitetail shiner	0	0	0	4	1	5
Nocomis platyrhyncus	bigmouth chub	0	0	0	1	1	2
Rhinicthys atratulus	blacknose dace	1	3	2	21	12	39
Semotilus atromaculatus	creek chub	0	2	1	11	26	40
Catostomidae							
Hypentilium nigricans	northern hogsucker	0	0	0	2	0	2
Centrarchidae							
Lepomis cyanellus	green sunfish	3	1	1	2	0	7
Micropterus dolomieu	smallmouth bass	10	2	0	10	4	26
Percidae							
Etheostoma caeruleum	rainbow darter	0	0	0	0	5	5
Etheostoma variatum	variegate darter	0	0	0	0	3	3
	Total	19	9	7	56	60	149

New River Gorge National River Fish Data

Eprhiam Creek

		Seasons					
Species	**Common Name**	**Fall 2001**	**Spring 2002**	**Summer 2002**	**Fall 2002**	**Spring 2003**	**Total**
Cyrpinidae							
Campostoma anomalum	stoneroller	0	0	0	0	9	9
Clinostomus funduloides	rosyside dace	0	1	0	0	0	1
Rhinychthys atratulus	blacknose dace	0	1	0	0	0	1
Semotilus atromaculatis	creek chub	0	0	0	0	2	2
Centrarchidae							
Micropterus dolomieu	smallmouth bass	0	3	0	7	1	11
Percidae							
Etheostoma caeruleum	rainbow darter	0	3	0	0	1	4
Etheostoma variatum	variegate darter	0	0	0	0	15	15
	Total	0	8	0	7	28	43

New River Gorge National River Fish Data

Farley Creek

Species	Common Name	Fall 2001	Spring 2002	Summer 2002	Fall 2002	Spring 2003	Total
		Seasons					
Cyprinidae							
Campostom anomalum	central stoneroller	62	35	38	181	131	447
Clinostomus funduloides	rosyside dace	0	0	3	0	0	3
Cyprinella galactura	whitetail shiner	0	0	0	149	0	149
Notropis hudsonius	spottail shiner	0	0	0	0	2	2
Notropis rubellus	rosyface shiner	0	0	0	25	0	25
Notropis telescopis	telescope shiner	2	0	0	260	0	262
Phoxinus oreas	mountain redbelly dace	0	0	2	0	1	3
Rhinichthys atratulus	blacknose dace	26	42	52	45	26	191
Semotilus atromaculatus	creek chub	1	8	4	6	10	29
Catostomidae							
Catostomus commersoni	white sucker	0	1	0	1	0	2
Hypentilium nigricans	northern hogsucker	0	2	0	0	2	4
Centrarchidae							
Lepomis cyanellus	green sunfish	0	14	10	15	6	45
Lepomis gibbosus	pumpkinseed	0	0	1	0	0	1
Micropterus dolomieu	smallmouth bass	26	20	1	25	1	73
Percidae							
Etheostoma blennioides	greenside darter	0	0	3	0	2	5
Etheostoma caeruleum	rainbow darter	60	167	104	112	123	566
Etheostoma variatum	variegate darter	6	22	13	14	13	68
	Total	183	311	231	833	317	1875

New River Gorge National River Fish Data

Fern Creek

		Seasons					
Species	**Common Name**	**Fall 2001**	**Spring 2002**	**Summer 2002**	**Fall 2002**	**Spring 2003**	**Total**
Cyprinidae							
Semotilus atromaculatus	creek chub	0	0	0	0	2	2

New River Gorge National River Fish Data

Fire Creek

		Seasons					
Species	**Common Name**	**Fall 2001**	**Spring 2002**	**Summer 2002**	**Fall 2002**	**Spring 2003**	**Total**
Cyprinidae							
Semotilus atromaculatus	creek chub	0	0	0	0	1	1
Percidae							
Etheostoma caeruleum	rainbow darter	0	1	0	0	0	1
	Total	0	1	0	0	1	2

New River Gorge National River Fish Data

Marr Branch

Species	Common Name	Seasons Fall 2001	Spring 2002	Summer 2002	Fall 2002	Spring 2003	Total
Cyprinidae							
Campostoma anomalum	central stoneroller	4	1	0	1	10	16
Clinostomus funduloides	rosyside dace	0	1	1	0	0	2
Cyprinella galactura	whitetail shiner	0	0	0	132	2	134
Luxilus albeolus	white shiner	0	0	0	0	1	1
Nocomis platyrhyncus	bigmouth chub	0	0	1	3	1	5
Notropis telescopus	telescope shiner	0	0	0	185	0	185
Pimephales promelas	fathead minnow	0	0	0	0	1	1
Rhinichthys atratulus	blacknose dace	0	3	1	12	2	18
Rhinichthys cataractae	longnose dace	4	0	0	0	0	4
Semotilus atromaculatus	creek chub	0	1	4	3	11	19
Catostomidae							
Catostomus commersoni	white sucker	0	0	0	7	1	8
Hypentilium nigricans	northern hogsucker	0	0	0	1	0	1
Salmonidae							
Salmo trutta	brown trout	0	0	0	0	1	1
Salivinus fontinalus	brook trout	0	1	0	0	0	1
Centrarchidae							
Ambloplites rupestris	rock bass	42	0	1	1	0	44
Micropterus dolomieu	smallmouth bass	4	5	0	49	5	63
Lepomis cyanellus	green sunfish	0	0	0	0	1	1
Lepomis macrochirus	bluegill	0	0	0	0	1	1
Percidae							
Etheostoma caeruleum	rainbow darter	0	3	0	0	1	4
	Total	54	15	8	394	38	509

New River Gorge National River Fish Data

Mill Creek

Species	Common Name	Fall 2001	Spring 2002	Summer 2002	Fall 2002	Spring 2003	Total
		Seasons (Fall 2001 - Spring 2003)					
Cyprinidae							
Campostoma anomalum	central stoneroller	32	15	0	13	7	67
Clinostomus funduloides	rosyside dace	3	0	0	0	0	3
Cyprinella galactura	whitetail shiner	0	0	0	59	0	59
Nocomis platyrhyncus	bigmouth chub	4	0	6	0	0	10
Notropis telescopus	telescope shiner	113	0	1	19	7	140
Rhinichthys atratulus	blacknose dace	12	4	8	9	10	43
Semotilus atromaculatus	creek chub	21	11	2	6	21	61
Catostomidae							
Hypentilium nigricans	northern hogsucker	1	0	2	1	0	4
Salmonidae							
Salmo trutta	brown trout	0	1	1	1	1	4
Salvelinus fontinalis	brook trout	1	3	1	0	5	10
Centrarchida							
Lepomis cyanellus	green sunfish	0	10	0	2	1	13
Micropterus dolomieu	smallmouth bass	3	0	2	0	1	6
Micropterus dolomieu	smallmouth bass	0	9	0	39	0	48
Percidae							
Etheostoma caeruleum	rainbow darter	5	6	0	5	6	22
	Total	195	59	23	154	59	490

New River Gorge National River Fish Data

Slater Creek

Species	Common Name	Fall 2001	Spring 2002	Summer 2002	Fall 2002	Spring 2003	Total
		Seasons					
Cyprinidae							
Campostoma anomalum	central stoneroller	8	1	0	27	18	54
Cyprinella galactura	whitetail shiner	0	0	0	25	0	25
Notropis telescopis	telescope shiner	0	0	0	1	0	1
Rhinichthys atratulus	blacknose dace	0	2	3	4	2	11
Semotilus atromaculatus	creek chub	9	5	0	0	0	14
Catostomidae							
Hypentilium nigricans	northern hogsucker	0	0	0	0	1	1
Salmonidae							
Salvelinus fontinalis	brook trout	0	0	1	0	0	1
Centrarchidae							
Lepomis cyanellus	green sunfish	19	16	0	0	0	35
Lepomis gibbosus	pumpkinseed	0	2	0	0	0	2
Lepomis macrochirus	bluegill	0	1	0	0	0	1
Micropterus dolomieu	smallmouth bass	2	1	7	9	0	19
Percidae							
Etheostoma caeruleum	rainbow darter	0	9	0	0	13	22
	Total	38	37	11	66	34	186

New River Gorge National River Fish Data

Short Creek

Species	Common Name	Fall 2001	Spring 2002	Summer 2002	Fall 2002	Spring 2003	Total
		Seasons					
Cyrpinidae							
Semotilus atromaculatus	creek chub	1	3	1	0	0	5
Ictaluridae							
Pylodictus olivaris	flathead catfish	0	1	0	0	0	1
Centrarchidae							
Lepomis cyanellus	green sunfish	0	1	0	0	0	1
Micropterus dolomieu	smallmouth bass	0	1	0	0	0	1
Percidae							
Etheostoma caeruleum	rainbow darter	0	4	0	0	0	4
	Total	1	10	1	0	0	12

New River Gorge National River Fish Data

Wolf Creek

Species	Common Name	Seasons: Fall 2001	Spring 2002	Summer 2002	Fall 2002	Spring 2003	Total
Cyprinidae							
Campostoma anomalum	central stoneroller	7	0	3	6	1	17
Cyprinella galactura	whitetail shiner	0	0	0	40	0	42
Notropis telescopus	telescope shiner	0	0	0	1	0	1
Rhinicthys atratulus	blacknose dace	3	9	18	210	36	276
Semotilus atromaculatus	creek chub	0	0	2	2	1	5
Salmonidae							
Salmo trutta	brown trout	2	0	0	0	1	3
Centrarchidae							
Lepomis cyanellus	green sunfish	3	2	2	4	0	11
Lepomis gibbosus	pumpkinseed	0	2	0	1	0	3
Micropterus dolomieu	smallmouth bass	5	16	1	21	2	45
	Total	20	29	26	285	43	403

CURRICULUM VITAE

David I. Wellman, Jr.

Education:

May 2004	West Virginia University Division of Forestry M.S. Fisheries Science
August 2001	University of Kansas Department of Environmental Studies B.S. Environmental Science, emphasis on aquatic ecology/water resources

Work/Research Experience:

Fisheries Biologist
Compliance Monitoring Laboratories, Inc.
50 Caney Branch Road
Chapmanville, WV 25508
September 2003 – present

Plan, organize, and lead fish and benthic surveys, stream delineations, and ephemeral/intermittent conversion zone determinations and write associated reports for private companies and public agencies. Aid in writing stream mitigation plans to improve fish habitat and also aid in writing Environmental Assessments. Use ArcGIS on a regular basis to develop maps of study areas and for use in stream mitigation plans.

Biology GS-6 – Student Career Experience Program (SCEP)
U.S. Geological Survey, Leetown Science Center, Biological Resources Division
11700 Leetown Road, Kearneysville, WV 25430
Supervisor: Dr. Barnaby Watten – Fisheries Biologist/Engineer
July 2003 – September 2003

I worked in the Restoration Technology Branch and aided in the construction, maintenance, and testing of equipment designed to treat streams impacted by acid mine drainage, acid precipitation, hydropower dam facilities and for the control of exotic species (e.g. zebra mussels and Asian clams). Conducted chemistry experiments to observe the fixation of phosphorus using flocs produced by the neutralization of acid mine drainage. Work time was shared with the U.S. Geological Survey, Water Resources Division in Charleston, WV.

Biology/Hydrology GS-6 – Student Career Experience Program (SCEP)
U.S. Geological Survey, Water Resources Division
11 Dunbar Street, Charleston, WV 25301
Supervisor: Mr. Hugh Bevans
January 1997 – August 1999 and May 2001 – September 2003

Responsibilities consisted of field trip preparation and surface water collection using part per billion protocols, recording water quality parameters with Hydrolabs, ecological surveys of streams (fish and invertebrates), habitat and geomorphological surveys of streams, servicing Data Collection Platforms (DCP) for continual water data, groundwater inventorying, water well pump test, gage house construction, boat operation/maintenance and data entry.

Graduate Research Assistant
West Virginia University, Division of Forestry
U.S. Geological Survey – West Virginia Cooperative Fish and Wildlife Research Unit
POB 6125 322 Percival Hall, Morgantown, WV 26506
Major Professor: Dr. Stuart Welsh
August 2001 – May 2004

Examined the order and timing of recolonization among fish species and if recolonization trends differed between native and nonnative fishes in flood-impacted tributaries of the New River Gorge National River, West Virginia. A synthesis of the New River Gorge's fish fauna was also updated and ArcGIS was used to create distributional maps and examine distributional patterns of fishes. A backpack electro-fisher was used to survey fish communities. Aided fellow graduate students with the following:

- Collected American eels to determine seasonal movement patterns.
- Surveyed fish and aquatic invertebrate communities to examine impacts of major highway construction
- Surveyed portions of the Elk River, West Virginia and tributaries in attempts to establish preferred habitat of the crystal and spotted darters.
- Surveyed fish communities in the Ohio River to determine preferred over winter habitat.

Hydrology GS-6 – Student Career Experience Program (SCEP)
U.S. Geological Survey, Water Resources Division
4821 Quail Crest Place, Lawrence, Kansas 66049
Supervisor: David Mau
August 1999 – May 2001

Conducted bathymetric surveys of reservoirs and analyzed bathymetric data using Hypack Max Software to reconstruct sediment and pesticide mass loading. Water quality samples using parts per billion protocols and sediment core samples were taken and analyzed for pesticides, trace elements, nutrients, fecal coliform, E. coli, phytoplankton, and chlorophyll a, b, c from reservoirs and streams. Continual water quality data were recorded with YSI 6600 and Data Collection Platforms (DCP). Became proficient in trouble-shooting YSI 6600 and DCP to ensure that satellite telemetry worked and data were transmitted. Other responsibilities included discharge measurements, gage house construction/maintenance, boat operation/maintenance and training of lower grade employees.

Papers Presented and Written:

1998 U.S. Geological Survey Public Liaison Meeting Charleston, West Virginia	Oral Presentation: *Bacteria in Ground and Surface Water* David I. Wellman
2002 American Fisheries Society Southern Division Mid-Year Meeting Little Rock, Arkansas	Oral Presentation: *Distributions of Fishes of the New River Gorge National River, West Virginia, Following Major Flood Events* David I. Wellman and Stuart A. Welsh
2002 West Virginia Wildlife Society Annual Meeting Weston, West Virginia	Oral Presentation *Distributions of Native and Nonnative Fishes in the New River Gorge National River* David I. Wellman and Stuart A. Welsh
2002 USGS – West Virginia Cooperative Fish and Wildlife Research Annual Meeting Morgantown, West Virginia	Oral Presentation: *Relationships Among Fish Distributions, Watershed Characteristics, and Floods in the New River Gorge National River* David I. Wellman and Stuart A. Welsh
2002 American Fisheries Society Annual Meeting Baltimore, Maryland	Oral Presentation: *Fish Distributions in the New River Gorge National River in Relation to Watershed and Stream Characteristics* David I. Wellman and Stuart A. Welsh
2002 National Park Service New River Gorge National River Glen Jean, West Virginia	Oral Presentation: *Progress on Fish Recolonization within Tributaries of the New River* David I. Wellman and Stuart A. Welsh
2002 2nd Annual Future Fisheries Professional Colloquium Cookeville, Tennessee	Oral Presentation: *Post-flood recolonization of fishes in high gradient, Appalachian Streams* David I. Wellman and Stuart A. Welsh

2003 Annual Tri-State Fisheries Meeting Ashland, Kentucky	Oral Presentation: *Recovery of Fishes in Small, High Gradient Streams Following Major Flood Events* David I. Wellman and Stuart A. Welsh
2003 – Final paper presented to the National Park Service, New River Gorge National River Glen Jean, West Virginia	Written: *Fishes of the New River Gorge National River* Stuart A. Welsh, David I. Wellman, and Dan A. Cincotta

Additional Training and Skills:

2002 – Department of Interior Electrofishing Safety Course

2002 – American Red Cross first aid and adult CPR

2001 – West Virginia University Advanced Ichthyology

2000 – U.S. Geological Survey Defensive Drivers Course

1999 – Department of the Interior MOCC boaters training

1997 – U.S. Geological Survey Water Quality Principles Class

Computer Skills:

- ArcGIS
- Terrain Navigator
- Capture Statistical Software
- Microsoft applications (Word, Excel, Power Point)
- Hypack Max Bathymetry Software

Organizational Affiliations:

American Fisheries Society	Student member, 1997 - present
West Virginia University Student Chapter of the American Fisheries Society	Member, 2001 - present

Awards:

1997 – U.S. Geological Survey STAR Award

1998 – U.S. Geological Survey STAR Award