SPOTTED DARTER STATUS ASSESSMENT

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DISCLAIMER

This document is a compilation of biological data and a description of past, present, and likely future threats to the spotted darter, *Etheostoma maculatum* (Kirtland). It does not represent a decision by the U.S. Fish and Wildlife Service (Service) on whether this taxon should be designated as a candidate species for listing as threatened or endangered under the Federal Endangered Species Act. That decision will be made by the Service after reviewing this document; other relevant biological and threat data not included herein; and all relevant laws, regulations, and policies. The result of the decision will be posted on the Service's Region 3 Web site (refer to: http://midwest.fws.gov/eco_serv/endangrd/lists/concern.html). If designated as a candidate species, the taxon will subsequently be added to the Service's candidate species list that is periodically published in the Federal Register and posted on the World Wide Web (refer to: http://endangered.fws.gov/wildlife.html). Even if the taxon does not warrant candidate status it should benefit from the conservation recommendations that are contained in this document.

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Common Name(s): spotted darter

Scientific Name
Etheostoma maculatum Kirtland

Taxonomy
The spotted darter was originally described as *Etheostoma maculata* by Kirtland (1841). Jordan and Eigemmann (1885) emended the species epithet to *maculatum* to conform with the neuter gender of *Etheostoma*, and reported on skull and vertebral characters. The spotted darter was subsequently listed under the genera *Etheostoma*, *Nothonotus*, and *Poecilichthys* by various workers through the early 1950s. Bailey et al. (1954), and Bailey and Gosline (1955) reduced the number of darter genera to three (*Ammocrypta*, *Etheostoma*, and *Percina*), with the spotted darter, *Etheostoma maculatum*, placed in subgenus *Nothonotus*; *Poecilichthys* was treated as a junior synonym of genus and subgenus *Etheostoma*. Three subspecies were subsequently recognized by Zorach and Raney (1967); e.g., *Etheostoma maculatum maculatum* Kirtland in the Ohio River system including the Wabash and Green river systems, *E. m. sanguifluum* (Cope) in the upper Cumberland River system below Cumberland Falls, and *E. m. vulneratum* (Cope) in the upper Tennessee River system. These subspecies have all since been elevated to distinct species within the genus *Etheostoma*, subgenus *Nothonotus*; e.g., *E. maculatum* (spotted darter), *E. sanguifluum* (bloodfin darter) and *E. vulneratum* (wounded darter) by Etnier and Williams (1989).

PHYSICAL DESCRIPTION AND CHARACTERISTICS

The spotted darter (Figure 1 in Appendix 1) is a member of the Perch family (Percidae) which contains such common freshwater game species as walleye (*Stizostedion vitreum*) and yellow perch (*Perca flavescens*). The fishes of the family Percidae are characterized by the presence of a dorsal fin separated into two parts, one spiny and the other soft (Kuehne and Barbour 1983). The darters differ from their percid relatives in being much smaller in overall size and having a more slender shape. Darters, exclusive of some species of the genus *Percina,* have a vestigial swim bladder (Evans and Page 2003). This characteristic decreases buoyancy, supposedly allowing them to remain near the bottom with little effort (Kuehne and Barbour 1983).

The spotted darter is part of the largest and most diverse darter genera, *Etheostoma*, of the family Percidae (Page 1983, Kuehne and Barbour 1983). *Etheostoma* is Latin for, to strain mouth and the specific epithet *maculatum* is Latin for, spotted (Burr and Warren 1986). Darter species within the genus *Etheostoma* differ from those in the genus *Percina* in possessing scales on the midline of their belly that are similar in shape and size to the scales on their flanks (Stauffer et al. 1995). Species within the sand darter genera, *Crystallaria* and *Ammocrypta*, differ from those within *Etheostoma* in being excessively elongate, and by the naked midline of their belly (Bailey et al. 1954). Within *Etheostoma*, only *E. acuticeps* has a sharper snout than *E. maculatum* (Page

1983, Kuehne and Barbour 1983). Other distinguishing morphological characteristics of the spotted darter include: laterally compressed body, unequal jaws, short pectoral fins, an absent/weak suborbital bar, and a rounded posterior edge of the caudal fin (Zorach and Raney 1967). Spotted darters superficially resemble bluebreast darters (*E. camurum*), but the two can be distinguished by the latter having a black margin on its soft dorsal, caudal, and anal fins (Stauffer et al. 1995). Small spotted darters can resemble Tippecanoe darters (*E. tippecanoe*); however, the two can be distinguished by the latter having an incomplete lateral line (Stauffer et al. 1995). *Etheostoma maculatum* is fairly long-bodied relative to other darters, often exceeding 60 millimeters (mm) and even reaching 75 mm in standard length (SL) (Page 1983, Kuehne and Barbour 1983). The opercle and belly are scaled, the cheek is slightly scaled to unscaled, and the nape and breast are unscaled (Page 1983). Lateral line counts are usually 56 to 65 scales, and vertebrae number 37 to 39 (Kuehne and Barbour 1983).

Sexual dimorphism is very pronounced in the spotted darter (Raney and Lachner 1939); therefore, discussions of coloration should note the sex of the specimen (Figure 1 in Appendix 1). Very thorough presentations of the identifying characteristics of *E. maculatum*, by gender, are presented in Zorach and Raney (1967). That work is the primary source of information for the following summaries.

Males have black-edged red spots on the body and a bluish-green breast that intensifies in color at spawning time. The caudal fin has a white edge on the posterior border that contrasts with the predominantly dusky color of the rest of the fin, including the black membranes. The basi-caudal area is crossed by a pale bar that may be broken by four dark spots, none of which is as dark as the fin membranes. The first dorsal fin is uniformly dusky, except darker near the bases of the first and second membranes, and it has a narrow white border. The second dorsal fin is predominantly dusky, with membranes darker than rays, and a pale margin present. The anal fin is similar to the second dorsal, but the pale margin is more prominent. The pectoral fin is dusky, with rays darker than membranes. The pelvic fin is dusky with a whitish border on the outer half.

Females have dark spots on the sides of their bodies that, although larger, are more diffuse than the red spots of the males. The outer half of the caudal fin has dark spots on the rays and membranes. The basi-caudal spots are present, but they are obscured by the generally dusky appearance of the caudal base. Females, in contrast to the males, never possess a white/pale border on the dorsal fins. The first dorsal fin is variably dusky, with discrete black spots occurring exclusively near the border, and a dark blotch on the lower half of the first membrane. The second dorsal fin has discrete round spots on the outer two-thirds of the rays and membranes, while the basal third is irregularly dusky. The anal fin is the same as the second dorsal, except that the first two or three membranes are uniformly dusky. The pectoral fin has clear membranes, but the rays are dusky with scattered elongated blotches. The pelvic fin is dusky with a milky-white border on the lower and posterior edges.

BIOLOGY AND NATURAL HISTORY

Spotted darters are most commonly found in the faster, deeper riffles of medium to large streams with plentiful gravel and rubble substrate (Raney and Lachner 1939, Page 1983, Burr and Warren

1986). Slight winter movement into the deeper areas within a riffle was indicated by Raney and Lachner (1939). Kessler and Thorp (1993) compared *E. maculatum* to the closely related *E. bellum* (orangefin darter) in a thorough evaluation of microhabitat segregation. They found that spotted darters occupied riffle areas of greater depth with larger sized, more diverse substrate than did orangefin darters, and hypothesized that opportunities for coexistence are enhanced by interspecific microhabitat partitioning that is linked to behavioral and morphological differences.

Spawning generally occurs from mid to late May, through June (Raney and Lachner 1939, Winn 1958a). The cheeks, isthumus, and breast of breeding males turn blue-green from the non-breeding brown coloration, and the dorsal and caudal fins of breeding males loose the slight orange-red appearance to become dusky (Raney and Lachner 1939). Spawning sites tended to be in the head portion of a riffle, in waters between one-half foot to two feet deep, and the minimum between-nest distance was reported as four feet (Raney and Lachner 1939, Winn 1958a). Highly adhesive pale, yellow eggs are deposited in tight wedge-shaped masses on the undersides of flat stones that are three to nine inches in diameter (Raney and Lachner 1939). Egg masses can contain up to 350 eggs, each about two mm in diameter, not all of which are laid at the same time, as suggested by egg maturity variation within the deposited masses and the number of mature ova in ovaries of ripe females (Raney and Lachner 1939). Although not directly observed for *E. maculatum*, Winn (1958b) speculated that the male is positioned beside the upside down female when the eggs are being deposited on the undersides of rocks. Only the male stays with the deposited eggs, facing upstream, either close to or under the stone, with only its head or tail protruding (Raney and Lachner 1939). Winn (1958a) reported that, after egg deposition, the area guarded by male spotted darters is a small and stationary territory that is inclusive of their feeding and escape ranges. Although egg cannibalism was not directly observed, the stomachs of some male and female *E. maculatum* specimens were found to contain spotted darter eggs (Raney and Lachner 1939). Larvae, five to six mm in total length (TL), with an oval yolk sac, hatched on June seventh from eyed eggs held overnight in an aquarium (Raney and Lachner 1939). Larvae averaged eight mm TL 48 hours after hatching, with the yolk sac still present. Individuals averaged 26 mm SL by late August, and their average length the following March was 32 mm (Raney and Lachner 1939). Males grew faster than females and averaged 48 mm SL at two years of age, while females averaged 44 mm SL (Raney and Lachner 1939). First spawning activity is reported to occur at two years for both males and females; males continue to spawn through year four and females through year five (Raney and Lachner 1939). Sex ratio data are highly variable; however, males outnumbered females in most collections (Raney and Lachner 1939).

According to Raney and Lachner (1939), spotted darters tend to remain isolated from other darters; however, they noted summer associations with catfish (*Noturus flavus* and *N. eleutherus*), several minnows (*Nocomis micropogon, Notropis rubellus, Campostoma anomalum anomalum*) and the hog sucker (*Hypentelium nigricans*).

Although consumption of their own eggs was noted for spotted darters by Raney and Lachner (1939), they reported that insect larvae made up 95% of the diet. Based on 25 specimens taken by Raney and Lachner (1939) in June, the bulk of the food items consisted of larval Diptera (mostly chironomids) and Trichoptera (caddisflies); while larval stoneflies (Plecoptera), mayflies (Ephemeroptera) and beetles (Coleoptera) occurred frequently enough to be considered

important, along with adult water mites (Hydracarina). Page's (1983) summary of the spotted darter's diet supports earlier reported evidence of the importance of larval insects.

RANGE

Historical Distribution

Etheostoma maculatum is known to have occurred in the waters of the state of Indiana, and those eastward in the states of Ohio, West Virginia, Pennsylvania and New York, and southward into Kentucky (NatureServe Explorer 2002). Zorach and Raney (1967) examined a large number of museum specimens, representative of historical collection locations, in their analysis of the spotted darter's systematic characters. Unless footnoted otherwise, Table 1 (to follow) summarizes the historical information they presented:

Table 1. Summary of historical collections of the spotted darter. Information obtained, primarily, from Zorach and Raney 1967.

River System	State	County	Component	Year (s)
Allegheny	New York	Chautauqua	French Creek	1937, 1951
	Pennsylvania	Erie	French Creek	1935, 1938
		Crawford	French Creek	1935, 1959
		Mercer	French Creek	1935, 1938
		Venango	French Creek	1935
Mahoning	Ohio	Mahoning	Yellow Creek	1859
			Mahoning River	pre 1841(a)
Shenango	Pennsylvania	Mercer	Shenango River	1934 through 1936
Ohio	Ohio	Coshocton	Walhonding	1960
		Ross	Deer Creek	1956
		Pickaway	Big Darby Creek	1930, 1943 (b), 1947, 1948, 1956, 1957, 1960, 1962
		Franklin	Big Walnut Creek	1897, 1958 through 1960, 1962
Green	Kentucky	Simpson	Drakes Creek	1970 (c)
		Allen	Trammel Fork	1970 (c)
		Green	Green River	1963
			Little Barren River	1956
		Monroe	Line Creek	1961
			Barren River	1961
		Allen	Barren River	1959
		Warren	Gasper River	1956
Upper Cumberland		Rockcastle	Rockcastle River	1876 and 1884 (both d)
Licking		Harrison	Triplet Creek	1892 (d)
Wabash	Indiana	Fulton	Tippecanoe River	1888 (e), 1890, 1899
		Carroll	Deer Creek	1888 (e)

(a) From Kirtland 1841, Type Locality. (b) From Trautman 1981. (c) From Cicerello 2003. (d) From Woolman 1892.
(e) From Jordan 1890.

Early, pre-1970 occurrence records do not exist for West Virginia waters (Stauffer et al. 1995, and pers. comm. with Dan Cincotta - West Virginia Department of Natural Resources).

Current Distribution

The following information on recent spotted darter occurrences in the United States was used to generate a distribution map based on USGS Hydrologic Units (Figure 2 in Appendix 1). Each of these units is identified by a unique hydrological unit code (HUC); see http://water.usgs.gov/GIS/huc.html. The shaded areas indicate hydrologic units containing waters in which recent (post 1970) occurrences of the spotted darter have been documented.

Kanawha River System. As mentioned just previously, reports of *E. maculatum* occurrences in West Virginia waters are relatively recent. The spotted darter has been collected at only two locations in West Virginia. Both records are from West Virginia Department of Natural Resource collection efforts on the Elk River of the lower Kanawha River basin (Stauffer et al. 1995, and pers. comm. with D. Cincotta). The first record came from the main-channel Elk River in 1976 immediately above Sutton Lake reservoir, while the second was from a 1991 survey made from a mid-river location which was below the reservoir (D. Cincotta pers. comm.). The mid-river location has been checked regularly over the last ten years, and the spotted darter continues to be present there; however, it has never been retaken at the 1976 collection site despite several attempts in the 1990s (D. Cincotta pers. comm.).

Allegheny River System. The spotted darter still occurs in the Pennsylvania portions of French Creek (Cooper 1983 and pers. comm. with Rob Criswell - Pennsylvania Game Commission). Although considered to be uncommon to rare the middle Allegheny (between Franklin, PA and Kinzua Dam), spotted darters are still present in this river system (R. Criswell, pers. comm.). The spotted darter also inhabits a 14 mile section of New York's French Creek (Smith 1985, and pers. comm. with Doug Carlson - New York State Department of Environmental Conservation). No specific collection dates or location details were available for these summaries. The sampling of West Branch French Creek (Chautauqua County) in 1992, produced the first record of the spotted darter in the New York portion of that stream (D. Carlson, pers. comm.).

Mahoning River System. According to Trautman (1981), the section of the Mahoning river where Kirtland collected his early specimens is almost devoid of fish life due to pollution and degraded water quality. Personal communication with Ted Cavender (Ohio State University) provided further evidence that the spotted darter has been eliminated from this river. According to Rob Criswell (pers. comm.), there are no definitive records for occurrences of the spotted darter in the Pennsylvania portion of the Mahoning river; only unverified information indicating a historical (circa 1890) presence in the Mahoning, which meets with the Shenango to form the Beaver River. He stated that the spotted darter is "evidently extirpated from the Shenango/Mahoning."

Shenango River System. As indicated in the summary text above for the Mahoning River, the current distribution of *E. maculatum* does not include the Shenango River system in Pennsylvania (R. Criswell, pers. comm.).

Ohio River System. Personal communications with Dan Rice (retired, Ohio Department of Natural Resources) revealed that, for the first time since the 1960s, the spotted darter was collected in the Walhonding River below the Mohawk Dam in 1999. A 1985 spotted darter occurrence was also recorded by Dan Rice when sampling the Kokosing River, which joins with the Mohican to form the Walhonding River. The rediscovery of the spotted darter in the Walhonding River was supported by Ted Cavender (pers. comm.), and by state occurrence records for Ohio provided by Randy Sanders (Ohio Department of Natural Resources, pers. comm). The Ohio state records of spotted darter occurrences include the Kokosing River, from 1983 to 1987. Trautman (1981) associated the occurrence of the spotted darter in the Olentangy River with a wide range of years, 1950 to 1980, and he noted that its occurrence was "unexpected" because the typically more numerous variegate darter had not been taken collected from that river. Recent occurrences of *E. maculatum* in Big Darby Creek, from 1979 through 1992, and in 1997, are supported by Ohio Department of Natural Resource records (R. Sanders, pers. comm.). This population looks to be expanding its range, upstream into Franklin County, to just beyond the confluence with Little Darby Creek (T. Cavender, pers. comm.). The Big Darby Creek population also appears to be expanding its range downstream, to the extent that it maybe about to re-occupy a historical Scioto River locality (T. Cavender, pers. comm.). Big Darby Creek differs from other upper Scioto River tributaries, such as the Olentangy River, and Big Walnut and Deer creeks, in having higher water quality (T. Cavender, pers. comm.). It is important to note that the spotted darter's current distribution no longer includes Deer or Big Walnut creeks (T. Cavender, pers. comm.).

Brant Fisher (Indiana Department of Natural Resources, pers. comm.) provided the following summary of recent (post 1970) occurrences of the spotted darter in Indiana tributaries of the Ohio River system:

Waterbody	County	Year
Blue River	Crawford, Harrison and Washington	1976-1984
	Crawford and Harrison	1987, 1993 and 1997
	Crawford, Harrison and Washington	1999-2000
South Fork Blue River	Washington	2000

According to Brant Fisher (pers. comm.), the mid-1970s occurrence of the spotted darter in the Blue River documented a previously unknown population in south-central Indiana (see also Baker et. al. 1985). The records for the years 1999 and 2000 are from the personal collection efforts of Brant Fisher (pers. comm.).

Green River System. Ron Cicerello (Kentucky State Nature Preserve Commission, pers. comm.) indicated that the spotted darter is likely extirpated from all Kentucky waters except those of the Green River system. Collections in the 1980s documented the presence of the spotted darter in the mainstem Green River, and in the Little Barren River, a tributary (Cicerello 2003). More

recently, spotted darters were collected at 20 sites over about 94 river-miles of the mainstem of the Green River (Cicerello 2003). Spotted darters were found, post-1990, in four tributaries to this 94-mile stretch of the Green River mainstem; e.g., in the Little Barren River (Green County), in Russell and Big Pitman creeks (Green County), and as a first record for Meadow Creek in Green County (Cicerello 2003). As recently as 2002, adults were collected and young of the year were observed in the mainstem of the Green River (Cicerello 2003). Cicerello (2003) concluded that the spotted darter was relatively common and evenly distributed in the Green River system; however, he noted that it has not been collected from the Green River downstream of Mammoth Cave National Park, despite the presence of suitable habitat. *Etheostoma maculatum* was also recently collected in Warren County Kentucky within the Barren River basin; e.g., in 1990 from the Barren River itself (below Lock and Dam No. 1) and in 2001 from its tributaries, the Gasper River and West Fork Drakes Creek (Cicerello 2003). Cicerello (2003) concluded that the spotted darter inhabits a fraction of its historical range in the Barren River basin, as it is currently restricted to the tributaries (West Fork Drakes Creek and lower Gasper River) and the contiguous Barren River, upstream to Lock and Dam No. 1.

Upper Cumberland and Licking River Systems. No data are available to support recognition of these river systems as components of the spotted darter's current distribution.

Wabash River System. According to Brant Fisher (pers. comm.), a 1985 record representing one location in Pulaski County signified the rediscovery of the spotted darter in the Tippecanoe River (see also Carney et. al. 1993). The 1997 collection efforts of Brant Fisher (pers. comm.) lead to the discovery a previously unknown population of *E. maculatum* in the East Fork White River. It is noteworthy to contrast this information, and that presented previously for the Blue and South Fork Blue rivers (of the Ohio River System), with the fact that Gerking's (1945) comprehensive survey questioned the spotted darter's existence in Indiana waters. He listed the spotted darter in an appendix of species whose occurrences were "probable or possible."

Distribution Summary. The preceding compilation of recent occurrences, by individual state, can be summarized by saying that the spotted darter's current distribution encompasses: two waters of the Allegheny River Drainage, eight waters of the Green River Drainage, one water of the Kanawha River Drainage, six waters of the Ohio River Drainage, and two waters of the Wabash River Drainage.

POPULATION ESTIMATES AND TRENDS

The summary text for *E. maculatum* presented in Page's (1983) comprehensive account of the darters states that: "The species can no longer be found at many localities where it previously occurred and seems to be disappearing over much of its former range." This statement is generally supported in the summary of the spotted darter's abundance presented in Kuehne and Barbour's (1983) textbook on the American darters. The summary text for *E. maculatum* in Page and Burr (1991) states that they are "extremely localized and uncommon." For Ohio waters, Trautman (1981) reported that there was no marked increase in spotted darter population size in any locality, pre or post 1950, and he speculated that there may be considerable variation in numbers from one year to another.

Kanawha River System. In West Virginia, the Elk River population appears to be divergent in viability, depending on proximity to the Sutton Lake reservoir. As stated previously in the *Current Distribution* portion of the RANGE section, the initial (1976) discovery was from the main channel of Elk River immediately above Sutton Lake reservoir, while the second (1991) record was from a survey of a mid-river location that was below the reservoir (D. Cincotta pers. comm.). The mid-river location (below the reservoir) has been checked regularly over the last decade, and the continued occurrence of the spotted darter has been confirmed there; however, *E. maculatum* has never been retaken at the initial collection site, above the reservoir, despite several attempts in the 1990s (D. Cincotta pers. comm.).

Allegheny River System. The spotted darter population in the Pennsylvania portion of French Creek has been stable over the past decade, but it has possibly declined a bit in Erie County (R. Criswell, pers. comm.). However, because there is little definitive population information available, no conclusions can be drawn regarding the status of *E. maculatum* in the Allegheny; although it may be stable, its numbers appear to be low (R. Criswell, pers. comm.). Rob Criswell (pers. comm.) also pointed out that the spotted darter has been significantly reduced in a Pennsylvania-state range context. A thorough study of New York portions of French Creek in 1991-1992 yielded an average estimated abundance of 0.1 individual per square meter (sq. m.), with a range of 0.03 to 0.33 individual per sq. m., for nine sites (D. Carlson, pers. comm.). Sampling efforts on the New York portions of French Creek produced the following data on total number of spotted darters caught per time frame (in parentheses): 16 (1937), 52 (1979-1980), 15 (1985-1989), about 100 (1991-1992), 1 (1994-1996), 1 (1999-2000) (D. Carlson, pers. comm.). These data should be interpreted with caution, however, because there is no assurance that they were collected under a standardized sampling protocol; i.e., number of sites, sampling frequency, sampling effort and sampling gear may have varied among and within time frames. An overall conclusion drawn from the 1991-1992 New York study of French Creek was that the abundance and age structure data were indicative of a healthy, self supporting population of spotted darters (D. Carlson, pers. comm.). It is important to note, however, that extensive sampling of 28 other sites in years 1994 and 1995 did not reveal any additional spotted darter locations within New York portions of French Creek, and that the current estimate of spotted darter population trends in New York is "unknown" (D. Carlson, pers. comm.).

Mahoning and Shenango River Systems. There do not appear to be any viable populations of spotted darters in these river systems (T. Cavender and R. Criswell, pers. comm.).

Ohio River System. There has been recent speculation that the spotted darter's presence in the Darby Creek system is expanding upstream from its known habitats near Fox, in Pickaway County, Ohio (D. Rice pers. comm.). The capture of a spotted darter from the Walhonding River in 1999, the first Ohio record since 1962, indicates the continued presence of a population in that river (D. Rice, pers. comm.). Although the Kokosing River population, discovered in Ohio in 1985, was scheduled to be sampled in 2000 (D. Rice, pers. comm.) no data were available. The populations associated with the distributions in Ohio plotted by Trautman (1981) were probably gone by the early 1960s (T. Cavender, pers. comm.). The frequency and occurrence of stream fishes in Ohio was compiled for the years 1979 through 1995 (Sanders et al. 1999). For the spotted darter, 105 individuals were recorded for five sites in three Ohio streams which

collectively represented a mean drainage area of 545 square miles (Sanders et al. 1999). To put these data into perspective, the spotted darter was the only taxa of the 23 extant members of the Family Pericdae to be listed as endangered in Ohio. In the Indiana tributaries, spotted darters are abundant in areas of desired habitat in the Blue River (B. Fisher, pers. comm.). According to Brant Fisher (pers. comm.) this population presumably increased dramatically in recent times, considering that it went undiscovered in Indiana for so long.

Green River System. As many as 25 individual spotted darters were collected in 1998 from the mainstem Green River at mile 225.8 near Munfordville, Kentucky (Cicerello 2003). In 2002, a total of 46 specimens (adult and young-of-year) were collected or observed at 11 of 30 sampling sites in the mainstem Green River (Cicerello 2003). Several tributaries of the Green River also support populations of *E. maculatum*; e.g., up to 10 individuals at one of five sites in the lower 24 miles of the Little Barren River, as many as 74 individuals from one site on the lower 20 miles of Russell Creek, three specimens collected in 2001 represented a first record for Meadow Creek, and one specimen collected in 1999 indicated that fish fauna are recovering from severe brine pollution in Big Pitman Creek (Cicerello 2003). Barren River basin populations in Kentucky appear to be less productive; e.g., five specimens collected in 1990 from the mainstem below Lock and Dam No. 1, one specimen collected in 2001 from the Gasper River, and three specimens collected in 2001 from West Fork Drakes Creek (Cicerello 2003). Cicerello (2003) speculated that the Gasper River population is limited to a rather small area around the collection site (in Warren County), and noted that several subsequent samplings of West Fork Drakes Creek failed to produce spotted darters.

Wabash River System. Although a substantial amount of effort has been recently exerted on the Tippecanoe to document the spotted darter's continued existence in this Indiana river, none have been found since 1985 when four individuals were collected near Winamac in Pulaski County, Indiana (Carney et al. 1993). The Tippecanoe River population may be extirpated or extremely reduced (B. Fisher, pers. comm.). In contrast, the 1997 discovery of a population of spotted darters in the East Fork White River has been successfully verified in very recent (into 2002) follow-up surveys covering Lawrence, Martin, Daviess and Dubois Counties (B. Fisher, pers. comm.). Brant Fisher (pers. comm.) considered *E. maculatum* to be abundant in areas of desired habitat in the East Fork White River.

SUMMARY OF THREATS

The information available in the published literature concerning threats to spotted darter populations lacks sufficient detail to formulate and test hypotheses on the responses of these populations to potential threats. Although broadly focused, early work by Ortmann (1909) addressed threats to the aquatic fauna, especially fishes, that inhabited the Ohio River and the Lake Erie drainages of western Pennsylvania. He recognized the impacts of human activities, both direct (intentional take) and indirect (water pollution). In a more recent multi-species assessment of threats, Deacon et al. (1979) found that of 251 fish taxa surveyed, 98 percent (%) were threatened by habitat modification, 37% by natural or artificial factors, 16% by range restriction, 3% by overexploitation, and 2% by disease. Information obtained from personal communications with several natural resource managers and conservation specialists established

a current list of purported threats to the spotted darter (Table 2). The most commonly cited threat to spotted darter persistence is the destruction and degradation of habitat as a result of impoundment, siltation, and pollution.

Table 2. Potential threats to spotted darter populations in various states.

State	Habitat Impacts	Overutilization	Disease or Predation
Indiana	unknown	unknown	unknown
Kentucky	impoundment, siltation	unknown	unknown
New York	siltation, pollution: animal waste, sewage plant failure, agricultural runoff (pesticides and fertilizers)	unknown	unknown
Ohio	water quality	unknown	unknown
Pennsylvania	water quality, pollution: agricultural runoff	unknown	unknown
West Virginia	siltation, pollution: domestic waste, mine drainage, industrial discharge, animal waste, low dissolved oxygen	unknown	unknown

Information supplied by B. Fisher - Indiana Department of Natural Resources; R. Cicerello - Kentucky State Nature Preserves Commission; D. Carlson - New York State Department of Environmental Conservation; T. Cavender - Ohio State University; R. Criswell - Pennsylvania Game Commission; D. Cincotta - West Virginia Department of Natural Resources.

The abundance of "unknown" entries for many of the tabulated categories above strongly indicates that there is an insufficient quantification of populations and therefore a diminished ability to ascribe population declines to potential threats. Clearly, these categories identify areas where research is needed.

A. The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range.

In a survey of 251 North American fishes, Deacon et al. (1979) found that 98 percent were threatened by habitat modification. In the southern United States, an estimated 28 percent of freshwater fishes are considered extinct, endangered, threatened, or vulnerable with the number of imperiled species increasing 125 percent over the past 20 years (Warren et al. 2000). Due to their geographically restricted distribution, freshwater fishes are highly susceptible to extirpation from localized habitat degradation through water impoundment, siltation, and stream flow modification (Warren et al. 2000). It is likely that these large-scale declines in species richness reflect the degradation of watersheds under the stress of growing human populations. Deacon et al. (1979) suggested that protection of suitable habitat and restoration of degraded habitat could slow population declines, though they admit that little has been done to address the loss of habitat and that more effort is needed.

Siltation

It has long been recognized that siltation alters aquatic habitats by reducing light penetration, changing heat radiation, covering the stream bottom, and retaining organic material and other debris (Ellis 1936). This translates into the disruption of reproductive behavior and alteration of food resources utilized by stream fish communities (Ellis 1936). Investigating the effects of siltation on fish communities in Missouri streams, Berkman and Rabeni (1987) found that as siltation increased, the distinction among riffle, run, and pool communities decreased and that the feeding guilds most impacted by siltation were those feeding from the substratum. Bhowmik and Adams (1989) provide an example of how sediment deposition has altered aquatic habitat in the Upper Mississippi River system where the construction of locks and dams has resulted in a successional shift from open water to habitats dominated by submergent and emergent vegetation. This successional process is not likely to favor species such as the spotted darter which rely on deep, fast-flowing, gravel and rubble raceways for population persistence (Page 1983). Waters (1995) discussed the sources and influences of sediment deposition on cold and warm-water fish habitats and concluded that the two most deleterious effects were the filling of interstitial spaces of riffles and reductions in overall water depth.

With respect to the biology of the spotted darter, Kessler and Thorp (1993) demonstrated the importance of deep-water areas (22.21 cm on average) with gravel and cobble substrates of high complexity and abundant interstitial space. Combined with behavioral observations which indicated that spotted darters were predominantly observed beneath rocks, these results suggest that substrate characteristics (i.e., arrangement and diversity) are particularly important to the life history of *E. maculatum* (Kessler and Thorp 1993) and darter segregation in general (Kessler and Thorp 1993, Kessler et al. 1995). These characteristics are likely to change with sediment inputs (see Bhowmik and Adams 1989), potentially reducing the availability of important refugia (Kessler and Thorp 1993). Similarly, because the spotted darter deposits eggs on the undersides of flat stones (Raney and Lachner 1939), it can be assumed that excessive siltation would reduce the abundance of suitable breeding habitat (Kessler and Thorp 1993). A recent report by Powell (1999) concluded that, although a factor like crop-land density influences many key water quality and fish habitat variables, fish community composition is primarily influenced by the cumulative effects of sedimentation.

Impoundment

Artificial impoundments destroy riffles and reduce flow, thereby increasing the amount of siltation which causes changes in substrate composition (see *Siltation* section). After the construction of dams on the North Fork of the Vermilion River and the middle Embarras River in Illinois, loss of riffle habitat and increased silt deposition resulted in the disappearance of the greenside darter, northern hog sucker, brindled madtom, blackside darter, and fantail darter (Smith 1968). According to Etnier and Starnes (1993), impoundments at Lake Cumberland, Cordell Hull, and Dale Hollow reservoirs in Tennessee have caused the apparent extirpation of the crystal darter (*Crystallaria asprella*) by altering big-river habitat in the region. Similarly, the Sutton Reservoir on the main channel of the Elk River in West Virginia may have played a role in the spotted darter's local extirpation immediately above the impoundment where the species has not been collected since 1976 (D. Cincotta, pers. comm.). However, it has been hypothesized

that spotted darters can persist in riffle habitats downstream from impoundments if water velocity and oxygen concentrations are sufficient (Baker et al. 1985).

Impoundments fragment stream habitat, blocking immigration and emigration between populations and preventing recolonization from source populations. For example, Ron Cicerello (pers. comm.) reported that reservoir construction on the Barren River and Green River Lakes in Kentucky destroyed spotted darter habitat and fragmented populations in the Green River. In addition, reservoir operation that results in water temperature and flow-rate changes precludes recolonization below dams (R. Cicerello, pers. comm.). Permanent refugia and transitory habitats providing hydrologic connectivity and dispersal routes can be rendered inaccessible by impoundment (Minckley 1995). As a result, recolonization is unable to counter local extinctions caused by demographic or environmental stochasticity. Small, isolated populations are more susceptible to environmental perturbation and demographic stochasticity, both of which may lead to local extinction (Lande 1988). Warren et al. (2000) point out that the range restriction in southern fishes underscores the significant threat of range fragmentation and isolation to their persistence.

Stream flow modification

Etnier (1972) found that the fish community assemblage changed in Middle Creek (a tributary to the East Fork of the Little Pigeon River in Sevier County, TN) after a flood-control project widened and straightened the channel. Some species declined or disappeared from the stream after rechannelization while others maintained stable population levels from an influx of upstream migrants. Overall dominance within the fish community shifted. These changes were attributed to substrate instability and decreased variation in the habitat structure, which ultimately contributed to a decrease in invertebrate fauna; an important dietary component of many fish species (Etnier 1972).

Water quality

Percid genera are sensitive to anthropogenic disturbance (Leonard and Orth 1986) as most are restricted to clear, fast-flowing water with clean gravel substrate (Page 1983). Specific association with clean gravel and rubble substrates make the spotted darter especially sensitive to changes in the chemical and physical characteristics of a stream. Maitland (1995) cited water pollution as "the single most significant factor in causing major declines in the populations of many fish species." However, in some parts of the spotted darter's current distribution, water quality improvements resulting from reduced pollutant loadings are thought to have resulted in an increase in some percid populations (Sanders et al. no date). The fact that freshwater fish populations are geographically confined to discrete freshwater systems with significant water movement, and therefore vulnerable to the effects of pollution, argues the importance of having multiple populations to ensure overall persistence (Maitland 1995). Pollutants can cause direct mortality to sensitive species and, at sub-lethal levels, can increase susceptibility to other threats (Maitland 1995). The issue of pollution is closely linked to habitat alteration and land use practices within the watershed. Major sources of aquatic pollutants include domestic wastes, agricultural runoff, and industrial discharges, all of which have been identified as threats to spotted darter populations (Table 2). Reash and Berra (1987) conducted a comparison between clean-water and polluted streams in Ohio. Polluted streams contained a simplified fish

community, characterized by the absence of pollution intolerant species including the fantail darter (*Etheostoma flabellare*). Polluted sites generally supported habitat and diet generalists that were able to tolerate degraded environments, while species with more specific habit preferences were absent (Reash and Berra 1987). There is also some evidence from Florida suggesting that water quality improvements during the 1960s to mid 1980s coincided with the recovery of fish assemblages to stable levels; however, questions remain as to whether or not improved water quality has maintained healthy fish populations (Walsh et al. 2003).

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes.
Although the spotted darter has no commercial value, live specimens may be collected for the aquarium trade (Walsh et al. 2003). Deacon et al. (1979) asserted that despite elaborate regulations to protect fish populations from over-harvesting, little has been done to address habitat loss. The authors also suggested that collection for scientific purposes should not be restricted since it provides managers with essential information for habitat improvement and species management activities. None of the states within the spotted darter's distribution indicated any known threat from overutilization (Table 2).

C. Disease and Predation.
None of the information obtained from states within the spotted darter's distribution indicated any known or potential threat from disease or predation (Table 2). Some natural predation by piscivorous fish and wildlife occurs (Page 1983). Commonly reported parasites of darters, in general, include metacercarial trematodes (black-spot disease) flukes, nematodes, leeches, spiny-headed worms, and copepods (Page 1983). Newly introduced species may act as predators of and/or competitors with native fish species, such as spotted darters. There appears to be need for research to address the threat potential associated with the introduction of new species, including those recognized to be invasive and exotic.

D. The Inadequacy of Existing Regulatory Mechanisms.
Contaminated sediment guidelines
The U.S. Environmental Protection Agency (EPA) has prepared technical guidance to address the exposure of sediment-dwelling organisms to contaminants that tend to partition into aquatic sediments (U.S. EPA 2000 a, b, c, d). Because the spotted darter feeds on benthic macroinvertebrates (Stiles 1972), an indirect exposure route to sediment-borne contaminants exists in impacted waters. A more recent EPA document on contaminated sediment acknowledges that the equilibrium partitioning sediment guidelines do not protect against synergistic or antagonistic effects of contaminants or bioaccumulative effects to benthos, and that they are not protective of wildlife health endpoints (U.S. EPA 2002-draft).

Other legislation
Legal protection afforded freshwater fishes is generally applied within the context of fish as an exploitable resource (Maitland 1995). Maitland (1995) described the 'no net habitat loss' policy of the Canadian Department of Fisheries and Oceans which requires developers to ensure that habitat loss will not result from the proposed action and if so, alter the proposal accordingly or provide for remediation. The Clean Water Act of 1964 includes similar provisions for protecting

water resources of the United States, although enforcement is often criticized as a significant problem for fish conservation (D. Cincotta, pers. comm.).

E. Other Natural or Manmade Factors Affecting its Continued Existence.

Genetic variation

Small, and increasingly isolated spotted darter populations may begin to suffer from decreasing within-population diversity as inbreeding among close relatives, which can lead to problems such as reduced fertility and fitness, increases in likelihood (Noss and Cooperrider 1994). Similarly, the random loss of adaptive genes through genetic drift may function to limit the ability of spotted darters to respond to changes in their environment (Noss and Cooperrider 1994). Small population sizes and inhibited gene flow between populations may increase the likelihood of local extinction (Gilpin and Soulé 1986).

CURRENT PROTECTIVE STATUS

The level of effort dedicated to documenting spotted darter occurrence and monitoring population status is generally minimal throughout its range and variable on a state-by-state basis. Therefore, each state has established a specific level of protection (or lack thereof) for *E. maculatum* as deemed necessary. Table 3 lists the spotted darter's protective status and National Heritage ranking by state, as well as its protective status and heritage ranking at the global and federal levels.

Table 3. Spotted darter's protective status at the global, federal, and state level.

Governmental Level	Protective Status	Heritage Status Rank
Global	none	G2
Federal (U.S.)	none	N2
Indiana	endangered	S1
Kentucky	none	S2
New York	threatened	S1
Ohio	endangered	S1
Pennsylvania	threatened	S2
West Virginia	species of concern	S1

G2 = globally imperiled; N2 = nationally imperiled; S1 = critically imperiled; S2 = imperiled. Information supplied by NatureServe Explorer 2002; B. Fisher - Indiana Department of Natural Resources; R. Cicerello - Kentucky State Nature Preserves Commission; D. Carlson - New York State Department of Environmental Conservation; T. Cavender - Ohio State University; R. Criswell - Pennsylvania Game Commission; D. Cincotta - West Virginia Department of Natural Resources.

The spotted darter is currently on Indiana's list of endangered fish species, although the state's Fish Technical Advisory Committee has recently recommended that it be down-listed to special

concern status (B. Fisher, pers. comm.). As a species of special concern in Indiana, the spotted darter would receive no special protection.

The spotted darter is considered threatened in New York state. This designation indicates that the spotted darter is likely to become imperiled in the foreseeable future and therefore makes it illegal to take, import, transport, posses or sell the species in New York (http://www.dec.state.ny.us/website/dfwmr/wildlife/endspec/). Based on its restricted distribution in New York (French Creek), Doug Carlson (pers. comm.) recommended that the spotted darter's protective status should be elevated to endangered in New York.

In Ohio, the spotted darter has disappeared from three central Ohio streams (e.g., the lower Olentangy River, lower Big Walnut Creek, and lower Deer Creek), remaining only in parts of Big Darby Creek (T. Cavender, pers. comm.). This limited distribution has resulted in its endangered status, thereby allocating funds for conservation efforts. The definition for endangered status in Ohio is as follows (R. Sanders, pers. comm.):

> ENDANGERED - A native species or subspecies threatened with extirpation from the state. The danger may result from one or more causes, such as habitat loss, pollution, predation, interspecific competition, or disease.

In Pennsylvania, *E. maculatum* is listed as "threatened." Rob Criswell (pers. comm.) shared the following relevant details from the Commonwealth of Pennsylvania Fish and Boat Code Act 1980-175 Title 30 Pennsylvania Consolidated Statutes Chapter 1, Section 102. Definitions:

> "Threatened species." All species and subspecies of fish which:
> (1) have been declared by the Secretary of the United States Department of the Interior to be in such small numbers throughout their range that they may become endangered if their environment worsens and appear on a Threatened Species List published in the Federal Register; or (2) have been declared by the executive director to be in such small numbers throughout their range that they may become endangered if their environment worsens and appear on the Pennsylvania Threatened Species List published in the Pennsylvania Bulletin.

Legal protection of threatened species is, therefore, afforded according to Commonwealth of Pennsylvania Fishing and Boating Regulations Title 58 Pennsylvania Code, Chapter 75. Endangered Species Section 75.1. Endangered species. -2305(b). This protection prevents the catching, taking, killing, possessing, importing to or exporting from the Commonwealth, selling, offering for sale, or purchasing, of and individual, alive or dead, or any part thereof, without a special permit from the Executive Director of the Commission.

In West Virginia, there are no state-established endangered species laws to protect and manage state or federal species of concern (D. Cincotta, pers. comm.).

SUMMARY OF LAND OWNERSHIP

There is no comprehensive database or publication containing specific occurrence records that are cross-referenced with site-specific ownership documentation for the entire geographic distribution of the spotted darter. In general, most streams are managed as state and/or federal navigable waters. However, land ownership within each watershed is variable and land use decisions on property within a watershed will likely have impacts on fish populations within individual streams. For example, Warren et al. (2000) reported that 11 percent of the 212 million acres of forested watersheds, which support the most ecologically significant streams and rivers in the southern United States, are publicly owned. What follows is a description of the available information concerning land ownership surrounding the streams where the spotted darter is know to occur.

In Indiana, The Nature Conservancy currently maintains an office on the Blue River (B. Fisher, pers. comm.). The state owns property along the lower section of the river (Harrison/Wyandotte State Forest Complex). Several state and federal properties are located along the East Fork White River, including the Williams Dam fishing area (Lawrence County), Hindonstan Falls fishing area (Lawrence County), Martin State Forest (Martin County), and the Hoosier National Forest (Martin and Lawrence counties).

In Kentucky, with the exception of Mammoth Cave National Park, riparian areas adjacent to the Green and Barren rivers where the spotted darter occurs are almost entirely privately owned (R. Cicerello, pers. comm.).

In New York, ownership of riparian areas is entirely private, and The Nature Conservancy owns one small area (D. Carlson, pers. comm.).

The ownerships of lands adjacent to French Creek in Pennsylvania are almost exclusively private (R. Criswell, pers. comm.). Much of the upper portion of the middle Allegheny watershed is publicly owned, although there is considerable private ownership in the lower portions (R. Criswell, pers. comm.).

The waters and the bottoms of the West Virginia streams and rivers are owned by the state (D. Cincotta, pers. comm.).

No information was available regarding ownership of the lands in Ohio that are associated with spotted darter habitat.

BENEFICIAL CONSERVATION ACTIVITIES

R. Cicerello (pers. comm.) reported that the Green River basin from Green River Lake Dam downstream to (but excluding) Nolin River in Mammoth Cave National Park is part of the Conservation Reserve Enhancement Program (CREP). As a result, $110 million has been appropriated to address agriculture-related water quality problems. In addition, water releases from Green River Lake Dam are being modified on a trial basis to determine if they will benefit

the downstream aquatic community, including rare fishes (R. Cicerello, pers. comm.). This is a joint project involving The Nature Conservancy, Southern Illinois University at Carbondale, and Eastern Kentucky University.

The French Creek Project in Pennsylvania has an ongoing public outreach, assistance, and education program in place; however, it does not directly address the spotted darter (R. Criswell, pers. comm.). A plan for future monitoring and conservation of aquatic resources by The Nature Conservancy was discussed in February of 2001 by a group of various natural-resource agency representatives from Pennsylvania and New York state (D. Carlson, pers. comm.). No details or additional information were available as a follow-up to this discussion about the French Creek Project.

In summary, there appears to be very few beneficial conservation activities, ongoing or planned, that are directed toward the spotted darter; specifically or in general.

MANAGEMENT ACTION AND RESEARCH NEEDS

A. Taxonomic, Ecological, and Distributional Status

In many parts of the spotted darter's range, the distributional status is uncertain. For example, Rob Criswell (pers. comm.) suggested that a comprehensive survey of the Allegheny River be conducted to identify suitable habitat for the spotted darter. This would lead to a better understanding of the its overall status in the state. Based on personal communications with several resource managers, there is also uncertainty about the ecology of *E. maculatum* and its response to human alteration of stream habitat (see THREATS section). These deficiencies call for conducting more research on *E. maculatum*, with an anticipation that the resulting information and data would aid future management decisions and planning efforts directed toward the spotted darter.

B. Habitat Protection and Restoration

Habitat protection and restoration will allow for the long-term successful conservation of freshwater fishes (Maitland 1995). Restoring and/or protecting spawning areas, and ensuring the maintenance of fast, deep riffles in medium to large streams with gravel and rubble substrate (Raney and Lachner 1939, Page 1983, Burr and Warren 1986) is likely to allow for population persistence of spotted darters, especially if conducted in concert with pollution control and abatement programs within their range. Management priorities should be given to high-quality habitat areas, currently supporting spotted darter populations, rather than heavily impacted areas because the costs of restoring degraded habitats are high. Walsh et al. (2003) stressed the need for surveys aimed at identifying suitable habitat as potential sources for translocation efforts (discussed below).

Specific recommendations for populations of *E. maculatum* inhabiting Kentucky's Green River include improving conditions to allow for recolonization in sub-basins that likely supported large, widespread populations (R. Cicerello, pers. comm.). Riparian zones should also be protected from further degradation that might contribute to stress on any existing spotted darter populations (R. Cicerello, pers. comm.).

In West Virginia, the only known mechanisms to protect the spotted darter, are stronger enforcement of the Surface Mining and Reclamation and Clean Water Acts of 1977 along with new federal projects targeting landowner (watershed) stewardship (D. Cincotta, pers. comm.).

C. Translocation

Ron Cicerello (pers. comm.) suggested that an attempt be made to reintroduce the spotted darter into the Barren River, upstream from the Barren River Reservoir, where the species occurred prior to impoundment. Similarly, augmentation of the small and possibly habitat-limited population upstream from the Green River Reservoir should be considered (R. Cicerello, pers. comm.). Rob Criswell (pers. comm.) believes that the reestablishment of a population on the Shenango River, where water quality has improved, would significantly improve the long-term prospect for the spotted darter in Pennsylvania.

Translocation should be considered before a species becomes critically imperiled (Poly 2003). Williams et al. (1988) provided criteria for the planning of fish translocations. It is critical that transplantation occur within the species' native range since ecological interactions within its natural distribution are likely to have fewer negative consequences than would introduction to a novel environment (Williams et al. 1988, Minckley 1995). Transplant sites should be afforded some degree of protection from habitat degradation (Williams et al. 1988), contain sufficient natural resources to support self-sustaining populations, and be large enough to sustain the range of natural variability needed to maintain local and regional diversity (Moyle and Sato 1991). Maitland (1995) emphasized that translocation should pose no threat to the parent stock from which propagules are selected, and noted that consideration be given to the genetic composition of the introduced stock so as to maintain genetic variation within and between populations. Other considerations for translocation include the potential for introduction of disease or parasites (Williams et al. 1988), and hybridization with closely related species (Williams et al. 1988, Minckley 1995). Post-introduction monitoring should be implemented to determine survival, recruitment, and population persistence (Williams et al. 1988).

Precedent for the translocation of imperiled darter species has been set by efforts to reestablish populations of the snail darter (Hickman and Fitz 1978), as well as duskytail darter (*Etheostoma percnurum*) and fringed darter (*Etheostoma crossopterum*) populations (Poly 2003). Poly (2003) stressed that the number of individuals released should be substantial and consist of multiple age classes, and he recommended that individuals be released into suitable habitat. Other factors to consider include sex ratio of inoculum, fecundity of the females, and potential interactions with species in the new locale (Poly 2003). Fringed darters displayed normal breeding activity after translocation, both juveniles and adults were present, and there was an increase in the number of nests discovered in subsequent years (Poly 2003). Efforts to move individuals at the beginning of their natural breeding season seem most effective for increasing the chances of locating a mate in the new habitat, prior to dispersal (Poly 2003). Similar steps could be taken to evaluate the potential for spotted darter translocation, if deemed necessary. It should be noted, however, that Poly (2003) suggested that a closely related species be used as a surrogate for initial investigations into the efficacy of translocation efforts prescribed for imperiled species.

D. Monitoring

Personal communications with the resource managers revealed that comprehensive survey efforts should be employed to clarify spotted darter distribution and abundance, as well as identify potential habitat. All management actions should be based on adequate monitoring to evaluate success of programs and guide future efforts to protect imperiled species. A statewide survey for the spotted darter was recently completed in Indiana (B. Fisher, pers. comm.). Efforts are now underway to determine if the spotted darter is extirpated from the Tippecanoe River. Similar surveys should form the foundation for long-term population monitoring efforts. As with other species of concern, the spotted darter should be monitored on at least a five-year rotation (D. Cincotta, pers. comm.). Long-term monitoring should be initiated as soon as possible to ensure that future decisions are made within the context of future population trends, and re-sampling of historic occurrence sites should be conducted to augment trend information. Monitoring efforts should be standardized across geographic and political boundaries to facilitate comparisons in both space and time (Maitland 1995).

E. Watershed Management

Efforts should be made to address watershed-scale stressors to spotted darter populations and/or habitat in order to address multiple stressors that may or may not originate in close proximity to extant populations (see THREATS section). These efforts should establish a consensus among stakeholders from a diverse assemblage of interest groups within a watershed. Although not a part of the spotted darter's range, the Cahaba River Basin Clean Water Partnership (Cahaba River Basin CWP; www.cahabariver.com) is s good example of such an effort. The partnership is comprised of representatives from various interest groups, within the basin, and is tasked with identifying environmental problems within the basin and discussing appropriate improvement measures. Using comparative risk assessment, the partnership has prioritized ecological stressors to incorporate the effects of environmental impacts, the feasibility of improvement measures, and associated consequences of watershed protection strategies. Recommendations and policy measures can then be identified and action can be taken to protect important stretches of the river. In general, watershed management efforts to reduce siltation and channel modification within watersheds should receive high priority.

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Appendix 1

Figures 1 and 2

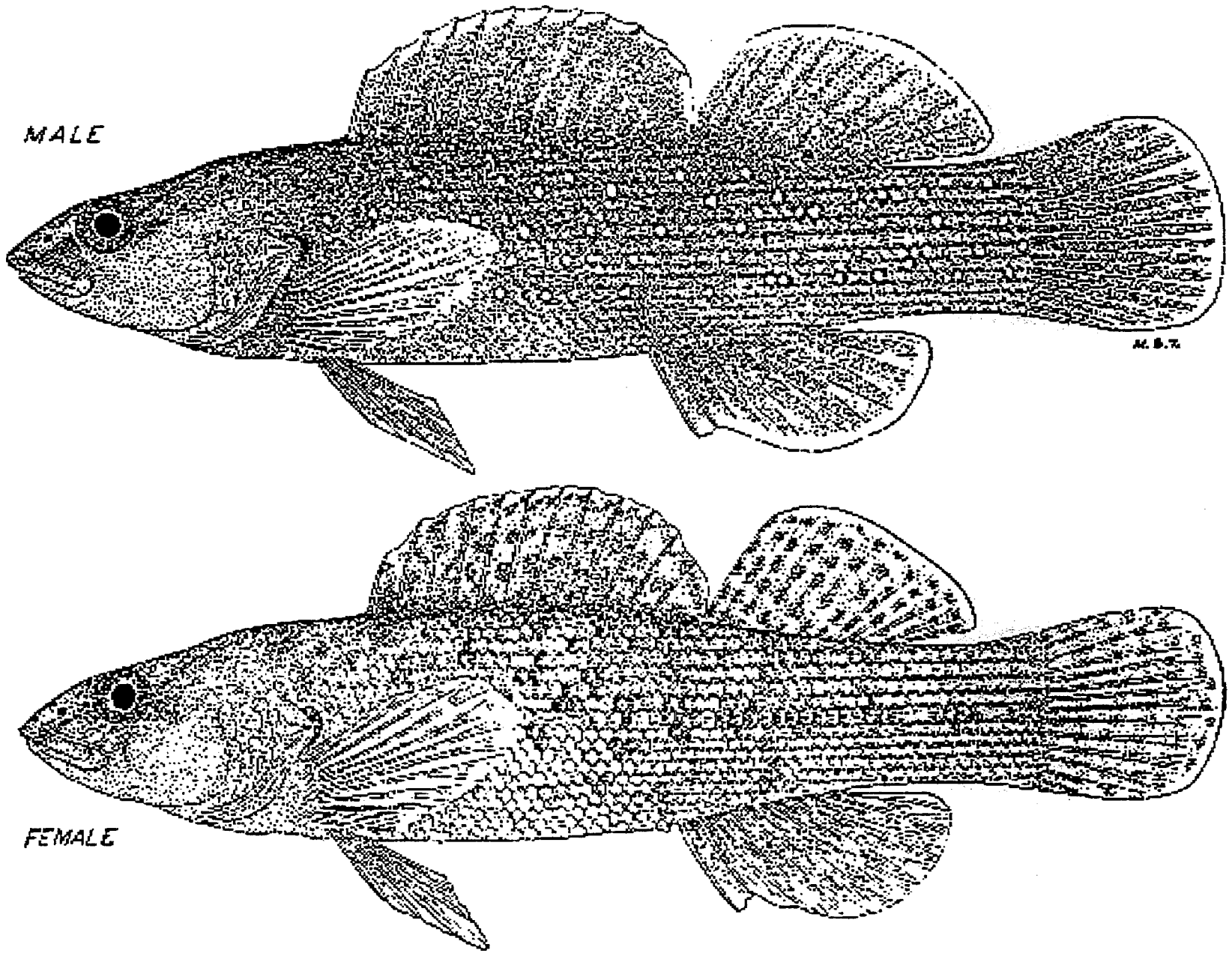

Figure 1. Spotted darter, *Etheostoma maculatum* (Kirtland). Sketch by M. B. Trautman from Trautman (1981).

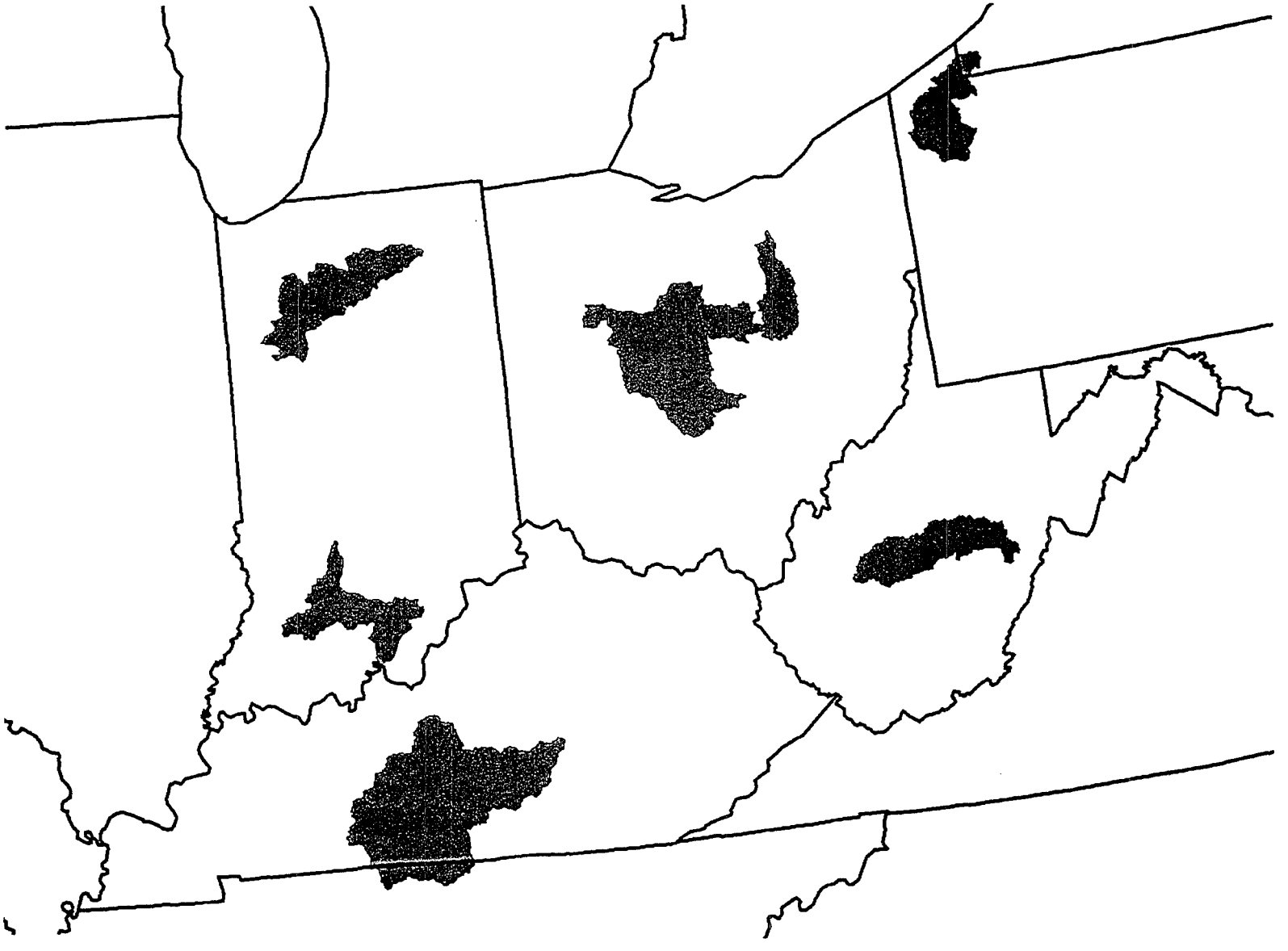

Figure 2. Current distribution of the spotted darter. Shaded areas indicate USGS Hydrologic Units containing rivers, streams, and/or creeks with post-1970 occurrence records.

Appendix 2

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