Transactions of the Illinois State Academy of Science
(1996), Volume 89, 1 and 2, pp. 73-91

Nonnative Fishes in Illinois Waters: What Do the Records Reveal?

Brooks M. Burr[1], David J. Eisenhour[1], Kenneth M. Cook[1], Christopher A. Taylor[2], Gregory L. Seegert[3], Randy W. Sauer[4], and Elmer R. Atwood[4]

Department of Zoology, Southern Illinois University, Carbondale, Illinois 62901-6501[1]
Illinois Natural History Survey, Champaign, Illinois 61820[2]
EA Midwest, 444 Lake Cook Road, Suite 18, Deerfield, Illinois 60015[3]
Division of Fisheries, Illinois Department of Conservation, Hazlet State Park Office, Carlyle, Illinois 62231[4]

ABSTRACT

Recent collections (late 1980s, early 1990s) in Illinois waters demonstrate convincingly that the State's fish faunal diversity is expanding rapidly from introductions of nonnative fishes through purposeful (e.g., stockings, transplantations, release of aquarium pets) and unintentional means (e.g., release of ship ballast water, dispersal of fishes from flooded aquaculture ponds, mixed stockings), by the natural invasion of Illinois waters from stockings in other states, or by movement of fishes made possible by changing environmental conditions. Two Asian exotics (Grass Carp [*Ctenopharyngodon idella*] and Bighead Carp [*Hypophthalmichthys nobilis*]) are now established in Illinois waters and the White Perch (*Morone americana*) has dispersed rapidly and probably is now established in the state. In addition, vouchered specimens indicate a somewhat widespread but sporadic occurrence in Illinois of two other exotics, the Rudd (*Scardinius erythrophthalmus*) and Silver Carp (*Hypophthalmichthys molitrix*). Collections from 1993-1994 made in the Chicago Sanitary and Ship Canal reveal that the exotic Oriental Weatherfish (*Misgurnus anguillicaudatus*) probably is established and its occurrence there may be the result of pet releases. Recent records also indicate that southern Illinois has been invaded by the Inland Silverside (*Menidia beryllina*), almost certainly established; the Striped Mullet (*Mugil cephalus*), a largely marine species spreading northward in the Mississippi River from the Gulf Coast; the Pirapatinga (*Piaractus brachypomus*), a neotropical exotic probably being released by disregarding hobbyists; and the Goldfish (*Carassius auratus*), now common in southern Illinois after the recent flooding of the Mississippi River. The Rainbow Smelt (*Osmerus mordax*) continues to be collected in the Mississippi River of southern Illinois, although somewhat more sporadically than in previous years.

INTRODUCTION

The history of introductions of nonnative fishes into Illinois waters mirrors the general history of introductions into North America. The Goldfish, *Carassius auratus*, was probably the first exotic fish to be introduced into North America (late 1600s). It was also the first nonnative species reported from Illinois (Nelson 1876), although it was not

considered established until many years later (O'Donnell 1935). The only known established exotic in Illinois at the time the first "Fishes of Illinois" was completed was the Common Carp, *Cyprinus carpio* (Forbes and Richardson 1908). By the late 1970s, six nonnative species were known to be reproducing (i.e., established) in Illinois waters (Smith 1979). Since Smith's (1979) survey of Illinois fishes, in which 13 species were considered to be nonnative, an additional seven species have become a part of the State's fish fauna either by accidental or purposeful introduction or by recent invasion of Illinois waters from both more southern or northern latitudes (Burr 1991). Because fish introductions into Illinois waters clearly have accelerated in recent years, documentation of the current status of several species is warranted. The potential ecological effects of nonnative fishes on native aquatic communities include habitat alterations (e.g., removal of vegetation); degradation of water quality; introduction of parasites and diseases; trophic alterations (e.g., increased predation, competition for food resources); hybridization; and spatial interactions (e.g., overcrowding, competition for spawning sites) (Taylor et al. 1984). On the positive side, the Asian carps reach large sizes and are a potential food source, especially for commerical markets; their potential as sportfishes is dubious.

Since the most recent review (Burr 1991) of nonnative fishes in Illinois, Johnston (1991) has provided records of the Threespine Stickleback (*Gasterosterus aculeatus*) in the Lake Michigan drainage; Page and Laird (1993a) and Laird and Page (in press) provided a summary and key to the identification of nonnative fishes in Illinois; Raibley et al. (1995) demonstrated reproduction of Grass Carp (*Ctenopharyngodon idella*) in the Illinois and upper Mississippi rivers; and in the gray literature, Raibley (1995) and the Long Term Resource and Monitoring Program at the Havana Field Station (1993) reported records for the White Perch (*Morone americana)* and the Grass Carp (*Ctenopharyngodon idella*) from the Illinois River and documented their probable establishment in Illinois. Reports of the Round Goby (*Neogobius melanostomus*) and presumably the Tubenose Goby (*Proterorhinus marmoratus*) as abundant in the Illinois waters of Lake Michigan have appeared recently on the national news and as major articles in Chicago newspapers. Both species are native to the Black and Caspian seas and apparently were introduced with ballast water into the Great Lakes (Robins et al. 1991). The Oriental Weatherfish (*Misgurnus anguillicaudatus*), an exotic ornamental fish, commonly kept in home aquaria and backyard ponds, is apparently established in streams of northeastern Illinois (Page and Laird 1993a,b; this report). The status of the Ruffe (*Gymnocephalus cernuus*), an additional European exotic introduced with ballast water into the Great Lakes and now established in Wisconsin and Minnesota, is uncertain in the Illinois portion of the Lake Mighican drainage.

The objectives of this paper are to: 1) document the relatively recent invasion and circumstantial evidence for reproduction in both the Grass Carp (*C. idella*) and the Bighead Carp (*Hypophthalmichthys nobilis*) in the inland waters of Illinois; 2) record the rapid 5-year dispersal and spread of the White Perch (*M. americana*) from Lake Michigan to Horseshoe Lake and its almost certain establishment in Illinois; 3) provide voucher records of the Striped Mullet (*Mugil cephalus*), a largely marine species, in Illinois waters; 4) provide vouchered records for the occurrence of the Oriental Weatherfish (*M. anguillicaudatus*) in the Chicago region and note the species' probable establishment there; 5) document the recent post-flood invasion of Goldfish (*C. auratus*)

into southern Illinois; 6) provide the first records of the exotic Pirapatinga (*Piaractus brachypomus*), a neotropical characoid, in southern Illinois; 7) note the occurrence of several introductions of the Rudd (*Scardinius erythrophthalmus*), an exotic native to Europe, not yet known to be established in Illinois; 8) provide evidence for the recent abundance and reproduction of the Inland Silverside (*Menidia beryllina*) in the Ohio and Mississippi River drainages of Illinois; 9) note the beginnings of probable establishment of the Silver Carp (*Hypophthalmichthys molitrix*) in Illinois; and 10) call attention to the continued persistence during the winter of the Rainbow Smelt (*Osmerus mordax*) in the Mississippi River.

METHODS AND MATERIALS

Records are based on collections made by the authors or collections deposited at the Illinois Natural History Survey (INHS), Southern Illinois University at Carbondale (SIUC), and a reference collection maintained at EA Midwest. Collections were made using 10 or 20 foot minnow and bag seines and (rarely) a boat-mounted electofishing unit and gill nets. Measurements are in mm standard length (SL) unless otherwise indicated. Most records reported here are from the late 1980s and early 1990s and are meant to demonstrate the rapid invasion that often occurs once a nonnative species gains access to continuous drainage systems. The use of common and scientific names of fishes follows the recommendations of Robins et al. (1991). Species accounts include catalog number, locality (legal locality in parentheses when available), major drainage (in parentheses), county, date of capture, and also in parentheses the number of specimens followed by their range in SL. Genera and species are treated alphabetically within the general phylogenetic scheme presented by Robins et al. (1991).

We have endorsed here the use of the term nonnative to encompass any fish species that is either an exotic, a transplant, or a recently invading species from outside of Illinois. Terminology and definitions associated with nonnative fishes follow Shafland and Lewis (1984) and Hocutt (1985).

RESULTS

Goldfish
Carassius auratus
SIUC 22651 (4, 113.0 - 131.0 mm), pool (Old Clear Creek channel) at culvert (Clear Cr. Dr.) on Tamms Rd., 1.5 mi. E McClure (T14S, R3W, Sec. 11NW), Alexander Co., 11 November 1993; SIUC 22609 (2, 121.0 - 149.0 mm), ditch adjacent to Clear Creek levee (Mississippi R. Dr.), 1.5 mi. NNW Gale (T14S, R3W, Sec. 27SW), Alexander Co., 4 December 1993; SIUC 22626 (3, 106.1 - 111.0 mm), ditch (Clear Cr. Dr.) next to road, 2.0 mi. SE McClure (T14S, R3W, Sec. 22SW), Alexander Co., 4 December 1993; SIUC 22918 (2, 111.8-124.9 mm), Mississippi River (Gulf of Mexico Dr.), at Grand Tower, Devil's Backbone Park (T10S, R4W, Sec. 23SE), Jackson Co., 24 February 1994; SIUC 22959 (12, 100.0-132.00 mm), Mississippi River (Gulf of Mexico Dr.), at Grand Tower aerial pipeline crossing (T10S, R4W, Sec. 23SE), Jackson Co., 23 April 1994; SIUC 24527 (1, 86.5 mm), Horseshoe Lake spillway (Cache R. Dr.), 1.0 mi. E of Miller City (T16S, R2W, Sec. 21NE), Alexander Co., 19 July 1995.

Remarks: Smith (1979) recorded the exotic *C. auratus* as common, especially in the Illinois River drainage, but had no records of the species from southern Illinois, although Gunning (1954) captured a specimen from Horseshoe Lake, Alexander County, in 1953 (SIUC 13962). Sporadic occurrences of the species are reported from western Kentucky (Burr and Warren 1986) and southern Missouri (Pflieger 1975). Numerous recent specimens appeared in our collections from various points in southwestern Illinois following the receding floodwaters of 1993, demonstrating that a number of source pools are now available in the area. All specimens were wild type in color and morphology and almost certainly do not represent the recent release of aquarium stock. It is likely the species invaded southern Illinois with the 1993 flood and took advantage of shallow flooded fields for reproduction and recruitment.

Grass Carp
Ctenopharyngodon idella
SIUC 21436 (4, 38.9 - 75.7 mm), Horseshoe Lake spillway [west side ditch] (Cache R. Dr.), 1.0 mi. E of Miller City (T16S, R2W, Sec. 21NE), Alexander Co., 17 April 1993; SIUC 22956 (1, 307 mm), Horseshoe Lake (Cache R. Dr.), west arm and near dam (T16S, R2W, Sec, 21NE), Alexander Co., 13 April 1994; SIUC 24458 (1, 32.8 mm), Horseshoe Lake spillway (Cache R. Dr.), 1.0 mi. E of Miller City (T16S, R2W, Sec. 21NE), Alexander Co., 14 June 1995; SIUC 24528 (1, 106.0 mm), same location as SIUC 24458, 19 July 1995; SIUC 23044 (2, 244-276 mm), Lake Creek (Cache R. Dr.), at Illinois Hwy. 3/127 crossing (T16S, R2W, Sec. 13), Alexander Co., 11 September 1994; SIUC 19962 (15, 12.6 - 29.6 mm), Cache River (Ohio R. Dr.), just E of jct. Hwy. 3 & 127, 1.5 mi. S Unity (T16S, R16E, Sec. 12SE), 4 August 1992; SIUC 20294 (1, 27.1 mm), Big Muddy River (Mississippi R. Dr.), at Rattlesnake Ferry (T10S, R3W, Sec. 27NW), Jackson Co., 4 August 1992; SIUC 20537 (1, 32.6 mm), Main Ditch Clear Creek (Mississippi R. Dr.), 4 mi. NNE Gale (T14S, R3W, Sec. 27NE), near mouth of Sexton Creek, Alexander Co., 20 September 1992; SIUC [pharyngeal arches examined and returned], Kaskaskia River, Pelican Pouch, about 4 mi. SSW Carlyle (T2N, R2W, Sec. 31), Clinton Co., summer 1991; SIUC 23897 (1, 49.6 mm), Mississippi River (Gulf of Mexico Dr.), Pool 25, Cockerill Hollow Access at Batchtown, RM 243.5, Calhoun Co., 11 September 1993.

Remarks: *Ctenopharyngodon idella*, a native of Asia, was introduced as a means of vegetation control in 1963 into experimental ponds in Arkansas and soon thereafter into impoundments in that state. It escaped almost immediately and dispersed throughout the Missouri-Mississippi mainstem (Pflieger 1978). By 1987 it was established in the Missouri River drainage, Missouri (Brown and Coon 1991). Greenfield (1973) and Stanley et al. (1978) reviewed the literature on the biology of *C. idella* and noted that it randomly spawns in strong currents of large rivers, apparently in response to rising water levels. Eggs must remain suspended in current for at least two days (approximate hatching time), so long reaches of flowing water are required for successful reproduction. These conditions were apparently enhanced during the recent floodings of the Mississippi River.

For years, triploid *C. idella* have been stocked into Illinois farm ponds and some lakes (e.g., SIUC Campus Lake) in an effort to control aquatic vegetation. Commercial fishermen have been catching adults and juveniles from the Illinois portion of the

Mississippi River for over 15 years (Paul Kimmel, pers. comm.). In the gray literature, Jennings (1989) reported four post-larval specimens (6 mm total length) from the Ohio River, near RM 945, in the vicinity of Metropolis, Illinois, collected in July 1987 by personnel of Hunter Environmental Services, St. Louis, Missouri. In addition, one of us (GLS) has collected two individuals (40 mm, 685 mm) from the Ohio River near Metropolis, in 1991-1992. A majority of the vouchered specimens reported here represent recent post-hatchlings or young-of-the-year and to our knowledge document the first evidence of spawning and recruitment of the species in the inland waters (i.e., waters other than the bordering big rivers) of Illinois [probable reproduction in the Big Muddy River was noted recently by Burr and Warren (1993) and in the Illinois and upper Mississippi rivers by Raibley et al. (1995)]. IDOC personnel captured 13 adult or subadult specimens (423-558 mm TL) from the Cache River at Perks bridge (T14S, R1E, Sec. 15), Pulaski County, on 27 September 1994. Grass Carp were not captured at this station or 25 others in a 1992 Cache River survey; these individuals almost certainly represent 1993 post-flood dispersal. As judged from the collection localities, the lower reaches of four river systems (Illinois, Big Muddy and Cache rivers, Clear Creek) in southern Illinois are all serving as apparent spawning or nursery sites. Because triploid *C. idella* are presumably incapable of producing viable offspring, we conclude that big river diploid stocks are now utilizing Illinois waters for some reproduction. Since the floods of 1993 and 1994, adult *C. idella* are common in both Horseshoe Lake and its outlet, Lake Ceek, Alexander County. We captured and released numerous subadults in Lake Creek during late summer 1994. In the approximately 23 years since *C. idella* was first reported from Illinois (Smith 1979), evidence for reproduction has occurred only in the last few years, indicating a somewhat lengthy period prior to establishment, especially when compared to *Morone americana* and *Menidia beryllina*.

Staff of the Long Term Resource Monitoring Program at the Havana, Illinois, field station recently (1994) collected juvenile *C. idella* less than 30 mm long from La Grange Reach, Illinois River, Beebe Lake near Banner (RM 135.7), and Quiver Lake near Havana (RM 122.2) (Raibley 1995). A 60-mm juvenile was taken at the Reach 26 field station on the Mississippi River. Gravid females also have been collected from the Illinois River. According to Raibley (1995) and Raibley et al. (1995) ploidy testing revealed diploid individuals. With all of these records taken together, there seems little doubt that *C. idella* is firmly established in Illinois.

Aquatic macrophytes dominate the diet of subadult and adult *C. idella,* although a few studies show consumption of animal matter (Laird and Page in press). While the impact of this species in Illinois waters remains to be seen, the potential for reducing cover used by a variety of fish species is certainly a potential adverse effect. In addition, excessive removal of aquatic macrophytes from large backwaters could impact waterfowl populations and restructure forage fish communities (Bettoli 1987). On the other hand, commercial fishermen in southern Illinois report *C. idella* to be a popular food fish and markets have developed for the sale of this species.

Silver Carp
Hypophthalmichthys molitrix
SIUC 17716 (1, 465 mm), Mississippi River (Gulf of Mexico Dr.), RM 160 at Merrimac (T2S, R11W, Sec. 8), Monroe Co., 25 March 1990; SIUC 23043 (1, 470 mm), Big

Muddy River (Mississippi R. Dr.), at Rattlesnake Ferry (T10S, R3W, Sec. 27NW), Jackson Co., 15 August 1994; SIUC 23046 (1, 492 mm), Horseshoe Lake (Cache R. Dr.), (T16S, R2W, Sec, 21NE), Alexander Co., August 1994; SIUC 24415 (2, 37.7-43.5 mm), ditch at Horseshoe Lake (Cache R. Dr.), 0.25 mi. W of spillway on Promised Land Road (T16S, R2W, Sec. 21), Alexander Co., 14 June 1995.

Remarks: This carp, a native of Asia, and first introduced into Arkansas in 1973, was then raised and stocked into municipal sewage lagoons, and by the early 1980s was reported from the natural waters of that state (Robison and Buchanan 1988). Sporadic records of this fish were known in Illinois beginning in about 1983, and only occasional specimens have begun to appear in our collections and the catches of commercial fishermen. With its spongelike gill rakers, *H. molitrix* is capable of straining organisms as small as 4 microns in diameter and is apparently efficient at digesting green and blue-green algae (Robison and Buchanan 1988). Its spawning requirements are similar (i.e., spawning occurs when water rises after heavy rains) to that of *H. nobilis* and *C. idella*, and recent capture of young-of-the-year in a ditch near Horseshoe Lake is the first evidence of successful spawning in Illinois waters and the United States. Considering that both *H. nobilis* and *C. idella* are now established in Illinois and have spawning requirements similar to *H. molitrix*, it is likely that this species will become established within the next ten years. Its impact on natural fish communities and the aquatic environment in general are unknown.

Bighead Carp
Hypophthalmichthys nobilis
SIUC 21715 (1, 232 mm), Horseshoe Lake spillway (Cache R. Dr.), 1.0 mi. E of Miller City (T16S, R2W, Sec. 21NE), Alexander Co., 29 June 1993; SIUC 23042 (1, 244 mm), same location as SIUC 21715, 21 July 1994; SIUC 23045 (1, 370 mm), same location as SIUC 21715, 11 September 1994; SIUC 24414 (2, 41.4-43.0 mm), ditch at Horseshoe Lake (Cache R. Dr.), 0.25 mi. W of spillway on Promised Land Road (T16S, R2W, Sec. 21), Alexander Co., 14 June 1995. SIUC 24403 (1, 44.5 mm), trib., Lake Creek (Cache R. Dr.), at Hwy. 3 crossing (T16S, R2W, Sec. 12SW), Alexander Co., 29 June 1995; SIUC 24003 (1, 250 mm), backwater of Cache River Ohio-Mississippi R. Dr.), just E of Sandusky (T15S, R1W, Sec. 18-19), Alexander Co., March 1995; SIUC 19280 (1, 535 mm), Big Muddy River (Mississippi R. Dr.) at Hwy. 3 crossing near Aldridge (T11S, R4W, Sec. 17SW), Union Co., 23 February 1992; SIUC 19282 (1, 446 mm), Horseshoe Lake (Mississippi R. Dr.), S of Granite City (T3N, R9W, Sec. 22-27), Madison Co., April 1992; SIUC 20308 (1, 23.4 mm), Big Muddy River (Mississippi R. Dr.), at Rattlesnake Ferry (T10S, R3W, Sec. 27NW), Jackson Co., 4 August 1992; SIUC 22240 (1, 670 mm), Cache River [diversion canal] (Ohio R. Dr.), 0.5 mi. upstream from Hwy. 3 in diversion canal near confluence of Cache & Mississippi rivers (T16S, R17E, Sec. 30NE), Alexander Co., 20 April 1993; SIUC 23040 (2, 476-506 mm), Big Muddy River (Mississippi R. Dr.), just S of Murphysboro (T9S, R2W, Sec. 7SW, NE), Jackson Co., 24 June 1994 ; SIUC 23919 (1, 210 mm), Kaskaskia River (Mississippi R. Dr.), near Covington (no precise legal locality available), Washington Co., 28 February 1994.

Remarks: According to Jennings (1988) this species was first introduced into Arkansas in 1972 for use in combination with other phytophagous fishes to improve water quality and increase fish production in culture facilities. It first began to appear in open waters in the

early 1980s in both the Ohio and Mississippi rivers (Jennings 1988). Probable spawning in Illinois was first documented by Burr and Warren (1993) in the lower Big Muddy River as judged from capture of a postlarval specimen (SIUC 20308). Recent capture of additional specimens representing young-of-the-year, subadults, and adults strongly suggests that reproduction and recruitment are occurring in Illinois waters. This is the most recent and rapidly invading exotic carp in southern Illinois. It appears to be using the lower reaches of the Big Muddy, Cache, and Kaskaskia rivers as spawning areas.

Additional specimens, not all vouchered in museum collections, indicate that the species may be relatively common in some southern Illinois waters. A commercial fisherman captured eight specimens (one vouchered as SIUC 22240) in the range of 13.6-18.1 kg in hoop nets on the lower Cache River in April 1993. Don Garver, IDOC District Fishery Biologist, examined and released 31 specimens ranging in total length from 427 to 594 mm and in weight from 0.86 to 2.8 kg caught by a commercial fisherman on the Big Muddy River in May 1994 (two vouchered as SIUC 23040). The fisherman had released a similar number of fish caught the previous day (he was not certain that what he caught was legal). Four adults ranging in length from 280 to 345 mm were captured and released by one of us (DJE) on two different dates in July 1994 from Lake Creek, Alexander County. Anglers have caught this species in the Kaskaskia River since 1992 and IDOC District Fishery Biologist Charlie Marbut identified a 533 mm-TL specimen in January 1994 from the tailwaters of Carlyle Lake.

Spawning of *H. nobilis* occurs in swift channels of large rivers (Jennings 1988). Flooding of lowland areas is a necessary requirement as these become the nursery areas for larvae and juveniles (Jennings 1988). These fundamental conditions and others summarized in Jennings (1988) were clearly met by the recent major flooding events in the Midwest and almost certainly account for the recent appearance of postlarvae and juveniles. The large numbers of adults appearing recently in commercial fishing harvests are presumably also related to flooding which probably redistributed adults in such a manner as to make them more accessible to fishermen. It would appear that this species is now established in Illinois waters and is capable of using the lower reaches of major Mississippi River tributaries as spawning reaches and/or nursery areas for larvae and juveniles.

The potential impact of this species is not adequately known. Markets for *H. nobilis* apparently have not become well established. Confusion over the correct identity of this species and the legality of taking this fish in commercial harvests has resulted in its consideration as a nuisance by some fishermen we have interviewed. The biological interaction of *H. nobilis* with other filter-feeding native fishes such as the Paddlefish (*Polyodon spathula*) warrants future investigation.

Rudd

Scardinius erythrophthalmus

INHS 64739 (1, 124.1 mm), Avon-Fremont Ditch (Illinois R. Dr.), at Grayslake (T45N, R10E, Sec. 26SE), Lake Co., 19 July 1988; INHS 64740 (1, 165.1 mm), Twin Lake (Fox R. Dr.), at Silver Springs State Park (T36N, R6E, Sec. 2/3), Kendall Co., 20 September 1988; INHS 28470 (3, 255.0-268.0 mm), Foli Dark Pond (Fox R. Dr.), at Plano (T37N, R6E, Sec. 27NE), Kendall Co., 15 September 1992; INHS 64430 (1, 80.0 mm),

Kankakee River (Illinois R. Dr.), 0.5 mi. N Custer Park (T32N, R9E, Sec. 13), Will Co., 1 August 1988; SIUC 22873 (1, 111 mm), Kankakee River (Illinois R. Dr.), 500 m downstream confluence with Horse Creek, E bank (T32N, R9E, Sec. 12), Will Co., 1 August 1989; SIUC 22874 (1, 121 mm), same location as SIUC 22873, 10 August 1989; INHS 65512 (1, 68.9 mm), Kankakee River (Illinois R. Dr.), 5.5 mi. ESE Ritchie (T32N, R10E, Sec. 36), Will Co., 17 May 1989; INHS 65419 (1, 82.2 mm), same location as INHS 65512, 31 May 1989; INHS 29751 (1, 175.0 mm), Des Plaines River (Illinois R. Dr.), at RM 273.3, 4 mi. S Minooka at mouth (T34N, R8E, Sec. 36NE), Grundy Co., 5 July 1990; SIUC 17614 (170, 39.7 - 58.4 mm), Carlyle Lake [bait dealer] (Kaskaskia R. Dr.), near Carlyle, Clinton Co., 21 July 1989.

Remarks: *S. erythrophthalmus* is native to Europe, Asia Minor, and interior Russia; beginning in the 1980s it underwent an explosive anthropogenic dispersal by the Arkansas fish farming industry "as a new, hardy, and colorful bait minnow" (Burkhead and Williams 1991). According to Burkhead and Williams (1991), the species has been distributed to at least 14 states and captured in the public waters of eight states. As indicated, a large number of individuals (SIUC 17614) were obtained from a bait dealer at Carlyle Lake and scattered records are available from several locations in northern Illinois beginning in 1988, with at least one record as recent as 1992 (INHS 28470). There is no evidence that this minnow is established in Illinois. The bulk of the records are of single fish, probably of subadult and adult age.

This species is primarily an inhabitant of lentic habitats and primarily occupies mid and surface waters. According to Wheeler (1969) the species is omnivorous, with adults feeding principally on insects and crustaceans, occasionally fish. Eggs are laid on submerged vegetation, along the shoreline, and on reed banks. It apparently reaches a large enough size (41 cm; 2 kg) to be popular with anglers in Europe (Wheeler 1969). Should this species become established in Illinois it will undoubtedly compete for limited resources in managed lakes, but it could provide a forage base for piscivorous sportfishes.

Oriental Weatherfish
Misgurnus anguillicaudatus
INHS 61129 (1, 113.0 mm), North Shore Channel (Lake Michigan Dr.), Dempster St., in Skokie (T41N, R13E, Sec. 14SE), Cook Co., 16 July 1987; INHS 61130 (1, 38.1 mm), same locality as INHS 61129, 19 September 1990; INHS 61131 (1, 55.5 mm), same locality as INHS 61129, 31 October 1990; SIUC 24002 (2, 131.0-138.0 mm), Chicago Sanitary and Ship Canal (Illinois R. Dr.), RM 321, Cook Co., 6 November 1994.

Remarks: *Misgurnus anguillicaudatus* is native to eastern Asia, principally northern China and Japan (Robins et al. 1991). In North America, this fish is established in several flood control channels in southern California, the headwaters of the Shiawassee River, Michigan, and the Boise River system, Idaho (Courtenay et al. 1986, Courtenay et al. 1987). One of us (GLS) has collected 13 specimens during 1993-1994, all from the upper reaches of the Illinois River drainage. As of 1994, vouchered records at SIUC and EA Midwest indicate the species is confined to the Des Plaines River/Ship Canal upstream of Brandon Road Lock and Dam (between RM 286 and 321). Page and Laird (1993a) and records at INHS indicate a wider range in northeastern Illinois including the

North Shore Channel in Skokie and perhaps Lake Michigan. We presume the source of this species in Illinois is via aquarium hobbyists releasing unwanted pets.

Captured specimens from the Sanitary and Ship Canal range in total length from 137 to 169 mm, the equivalent of adult size in the species native range (Sterba 1966). Smaller specimens from the North Shore Channel possibly represent release of small individuals or circumstantial evidence for recruitment. *M. anguillicaudatus* takes part in a rather elaborate spawning tryst that results in eggs being attached to the bases of aquatic plants (summarized in Breder and Rosen 1966). In its native range and also in Illinois this species occupies sluggish waters over mud substrates into which it commonly burrows. Due to an intestinal accessory respiratory organ it can survive low oxygen conditions. Hensley and Courtenay (1980) reported the species to be omnivorous. Considering these various life requisites, the number of specimens captured over a recent two-year period, and the latitude at which it occurs natively, *M. anguillicaudatus* is almost certainly established in northeastern Illinois. In Michigan, California, and Idaho, its established range has not expanded appreciably and we assume that only localized populations will continue in Illinois. If it does expand its range in Illinois, studies of the species reproductive biology and diet may help to determine its potential impact on native fishes.

Pirapatinga
Piaractus brachypomus
SIUC 19835 (1, 218 mm), Little Grassy Lake (Big Muddy R. Dr.) near Girl Scout Camp (T 10S, R1E, Sec. 19), Williamson Co., 15 June 1992; SIUC [examined and returned to angler, about same size as SIUC 19835], Southern Illinois University at Carbondale Campus Lake (Big Muddy R. Dr.) (T9S, R1W, Sec. 16), Jackson Co., 22 June 1992.

Remarks: *Piaractus* is native to South American freshwaters and serves as a valuable food fish as well as being a part of the ornamental fish trade. Burr and Warren (1993) reported this species from the Big Muddy River drainage as *Colossoma* sp. [pacu]. Since that paper was written, a taxonomic expert on pacus and their relatives has examined the specimens and provided us with the correct scientific name. More recently (1993) we obtained another specimen (SIUC 22241) from Lake Barkley, Kentucky. We know of no fish farms in the vicinity that raise this species nor of any state or federal agency that would be releasing this exotic into public waters. Apparently, humans have released their aquarium pets, which were probably too large for their aquaria, into nearby lakes rather than destroying them. This tropical fish almost certainly winterkills at this latitude and there is no reason to expect it to become established in north temperate waters. A single fish taken on a trotline, Mississippi River, south of Chester, Randolph County, September 1988 (Chester Herald Tribune, 1988), was reported as a piranha, but the accompanying photograph shows it to be *Piaractus*. An additional newspaper account (Randolph County Herald Tribune, 1994) of an angler catch of this fish (reported as a 14-inch piranha) in September 1994 is from Lake Baldwin (Kaskaskia R. Dr.), Randolph/St. Clair counties, a power-plant cooling lake that stays relatively warm throughout the year. It is possible that this species could survive and become established in lakes of this type.

Because the species strongly resembles some species of piranha (e.g., *Serrasalmus* and *Pygocentrus*), the capture of specimens by anglers often is reported in newspaper accounts and causes undue alarm among swimmers and boaters. The coincidental

appearance of four specimens of *Piaractus* from four different lakes within a three-year period seems unusual, especially that out of the thousands of fish caught over this time period, anglers would improbably catch one of the few specimens someone had released.

Rainbow Smelt
Osmerus mordax
SIUC 22804 (5, 54.0 - 61.4 mm), Mississippi River (Gulf of Mexico Dr.) at Grand Tower aerial pipeline crossing (T10S, R4W, Sec. 23SW), Jackson Co., 20 March 1987; SIUC 24087 (39, 45.6-66.8 mm), same location as SIUC 22804, 1 April 1995; SIUC 22803 (1, 64.0 mm), Mississippi River (Gulf of Mexico Dr.) at Venice boat ramp (T3N, R10W, Sec. 35), Madison Co., 20 March 1987; SIUC 22801 (2, 54.6 - 57.2 mm), Mississippi River (Gulf of Mexico Dr.) at Chester boat ramp (T7S, R7W, Sec. 30), Randolph Co., 20 March 1987; SIUC 23604 (18, 34.5-47.0 mm), Mississippi River (Gulf of Mexico Dr.), just downstream of mouth of Marys River (T7S, R6W, Sec. 33), Randolph Co., 12 November 1994.

Remarks: Mayden et al. (1987) reviewed the records and literature on the distributional history of *O. mordax* in the Mississippi River basin. They concluded that this species, otherwise unknown from the Mississippi River basin prior to 1978, reached the lower Missouri River mainstem and lower Mississippi River mainstem from escaped forage stockings in Lake Sakakawea, North Dakota, and possibly some may have originated from Lake Michigan stock. Approximately seven years elapsed from the initial stock of *O. mordax* in Lake Sakakawea until they were first captured in the free-flowing lower Mississippi River (Mayden et al. 1987). During winter months on the Mississippi River at Grand Tower from the late-1970s to the mid-1980s, *O. mordax* was the most common species along the shoreline (Klutho 1983). We report here the most recent (1994-1995) records of *O. mordax* from the Mississippi River and note that our survey work in the Mississippi River over the past several years has until recently revealed few specimens. The status of *O. mordax* in the Mississippi River basin remains uncertain, but its sporadic occurrence over the past six years in the mainstem suggests that it might best be considered an occasional winter transient.

Inland Silverside
Menidia beryllina
SIUC 20177 (47, 26.5 - 52.3 mm), Ohio River (Mississippi R. Dr.), 3 mi. ENE Olmstead at Lock & Dam 53 (T15S, R2E, Sec. 19), Pulaski Co., 4 August 1992; SIUC 20173 (55, 23.8 - 46.2 mm), Ohio River (Mississippi R. Dr.), near Joppa (T15S, R3E, Sec. 26), Massac Co., 4 August 1992; SIUC 20307 (9, 33.0 - 43.5 mm), Big Muddy River (Mississippi R. Dr.), at Rattlesnake Ferry (T10S, R3W, Sec. 27NW), Jackson Co., 4 August 1992; SIUC 23595 (139, 22.6-77.2 mm), Kincaid Creek (Big Muddy R. Dr.) at Kincaid Lake spillway (T9S, R3W, Sec. 4NW), Jackson Co., 12 November 1994; SIUC 19119 (25, 59.1 - 74.7 mm), Ohio River (Mississippi R. Dr.), at Paducah (T16S, R5E, Sec.19), McCracken Co., Kentucky, 17 September 1991; SIUC 19167 (36, 56.3 - 62.7 mm), Ohio River (Mississippi R. Dr.), RM 944-948, near Shawnee Steam Plant, McCracken Co., Kentucky, August 1991.

Remarks: In a footnote, Smith (1979) stated that *M. beryllina* had been recently found in the Mississippi River of southern Illinois [INHS 26962, from Grand Tower in 1978,

captured by one of us (BMB)], indicating that he was unaware of any previous records of this fish in Illinois waters. Pflieger (1975) reported the species to be common in the Mississippi River from the mouth of the Ohio River southward. Since Smith's (1979) report, no *M. beryllina* had been taken in Illinois waters until the 1990s, when the species was found to be common in the lower Ohio River by several independent investigators. The Ohio River records are the first to be reported (outside of the gray literature) for the mainstem. We also document the presence of this species in the lower Big Muddy River. The latter record was noted by Burr and Warren (1993) and appears to represent the northernmost record of this species in the Mississippi River basin. Size ranges of individuals indicate that reproduction has occurred (Stoeckel and Heidinger 1989), although it is unknown if the fish is established permanently in Illinois.

Menidia beryllina is abundant in Gulf Coastal waters and is frequently found established in pure freshwater rivers and lakes. We assume the Ohio River population of *M. beryllina* has only recently entered the lower mainstem, although it is abundant along the shoreline on both sides of the river. It is possible that *M. beryllina* entered the Ohio River via the Tennessee-Tombigbee waterway which now connects Gulf Coast drainages to the Ohio River, especially because of recent (1991) records from both Kentucky and Barkley reservoirs (Etnier and Starnes 1993). It is equally possible that the lower Mississippi River population expanded its range after the low water levels of the late 1980s created water-quality conditions (e.g., high dissolved solids) favorable for this species to disperse. Stockings in power-plant cooling reservoirs (i.e., Lake Baldwin and Lake of Egypt) for purposes of forage for sportfishes has occurred in the past few years but both of these reservoirs are a long distance (in terms of river miles) from capture sites reported here. Other fish biologists (Shute and Etnier 1994) have suggested that *Menidia* is invading the region from the lower Ohio-Mississippi rivers and not through the Tennessee-Tombigbee waterway.

Striped Mullet
Mugil cephalus
SIUC 21346 (1, 253 mm), Ohio River (Mississippi R. Dr.), at RM 944.2, 1 mi. downstream of Metropolis (T16S, R4E, Sec. 34), Massac Co., 18 July 1992; SIUC 17665 (1, 356 mm), Mississippi River (Gulf of Mexico Dr.), at Angelo Towhead, 1.0 mi. W of bridge at Cairo (T17S, R1w, Sec. 36), Alexander Co., 7 September 1989; INHS 57769 (1, 335.0 mm), Mississippi River (Gulf of Mexico Dr.), at RM 145.8, 5 mi. SW Maeystown (T4S, R11W, Sec. 22), Monroe Co., 20 September 1989.

Remarks: Burr et al. (1990) and Burr (1991) reported records of *M. cephalus* for the upper Mississippi River basin, noting that this species was known previously only as far north in the Mississippi River as southern Arkansas (Robison and Buchanan 1988). The record from the Mississippi River at mile 145.8 is the northernmost record known for this otherwise familiar resident of estuaries, salt marshes, and shoreline areas of the Atlantic and Gulf coasts (Etnier and Starnes 1993). Again we speculate that low water levels in the Mississippi River in 1988 and 1989 created water-quality conditions favorable for *M. cephalus* to reach the upper Mississippi River basin. A recent record (1993) from Kentucky Lake, Tennessee (Etnier and Starnes 1993), suggests that the Tennessee-Tombigbee waterway might possibly be another route of dispersal for this species to reach the mainstems of the Ohio and Mississippi rivers.

Because this species spawns offshore in marine waters, it will never be a persistent component of the Illinois fish fauna. *M. cephalus* is probably best considered a transient or periodic southern invader of Illinois waters.

White Perch
Morone americana
INHS 61096 (2, 121.3-141.4 mm), Lake Calumet (Lake Michigan Dr.), 1 mi. N Calumet City (T37N, R14E, Sec. 3-11), Cook Co., 20 June 1991; INHS 61097 (2, 112.1-106.8 mm), Calumet River (Lake Michigan Dr.), 130th Street in Calumet (T37N, R14E, Sec. 36), Cook Co., 26 June 1991; INHS 61098 (5, 81.9-127.3 mm), Little Calumet River (Lake Michigan Dr.), at I-94 bridge in Calumet (T36N, R14E, Sec.2NE), Cook Co., 21 June 1991; INHS 27890 (6, 89.0-128.5 mm), Wolf Lake (Calumet R. Dr.), William Powers Conservation Area (T37N, R15E, Sec. 20), 4 September 1990; INHS 29750 (1, 118.9 mm), Illinois River (Mississippi R. Dr.), RM 272.2, 3 mi. S Minooka, upstream of Dresden Island Lock & Dam (T34N, R8E, Sec. 26NE), Grundy Co., 2 August 1990; INHS 27889 (1, 54.9 mm), Illinois River (Mississippi R. Dr.), RM 170.7, Upper Peoria Lake, Lambie's Boat Harbor, Mossville (T9N, R8E, Sec. 3), Peoria Co., 20 September 1991; INHS 61171 (1, 55.4 mm), Illinois River (Mississippi R. Dr.), RM 180.8, Chillicothe (T28N, R3W, Sec. 5), Woodford Co., 10 September 1991; SIUC 21434 (1, 136 mm), mouth of Swan Lake at Illinois River mile 6 (Mississippi R. Dr.), 6.0 mi. N Grafton (T13S, R1W, Sec. 10), Calhoun Co., 19 November 1992; SIUC 22960 (3, 69.5-76.2 mm SL), Mississippi River (Gulf of Mexico Dr.), at Grand Tower aerial pipeline crossing (T10S, R4W, Sec. 23SW), Jackson Co., 23 April 1994; SIUC 23052 (1, 43.9 mm), Big Muddy River (Mississippi R. Dr.), at Rattlesnake Ferry (T10S, R3W, Sec. 27NW), Jackson Co., 22 August 1994; SIUC 24411 (1, 28.8 mm), Lake Creek (Cache R. Dr.), at 2nd bridge below Horseshoe Lake spillway (T16S, R2W, Sec. 14SW), Alexander Co., 29 June 1995. SIUC 23051 (4, 81.0-112.0 mm), Lake Creek (Cache R. Dr.), at Horseshoe Lake spillway (T16S, R2W, Sec. 21), Alexander Co., 25 June 1994; SIUC 21906 (4, 63.2 - 87.5 mm), culvert between formerly flooded fields (Mississippi R. Dr.), just SE Miller City (T16S, R2W, Sec. 20), Alexander Co., 6 November 1993.

Remarks: *M. americana* is an anadromous euryhaline species originally restricted to the North American Atlantic Coast where it is established in many freshwater lakes and rivers. Scott and Christie (1963) reviewed the spread of *M. americana* into the lower Great Lakes by movement of the species through the Mohawk River Valley and the Erie Barge Canal into Lake Ontario. By 1975, the species was established in western Lake Erie (Busch et al. 1977). Johnson and Evans (1990) hypothesized that above-average temperatures during the middle of the 20th century provided a window for *M. americana* to enter the Great Lakes and spread from there. Smith (1979) did not report this species from the Illinois waters of Lake Michigan; the first record for Illinois was of a single specimen captured in Belmont Harbor in 1988 (Savitz et al. 1989). By 1990-1991 *M. americana* had dispersed into the upper Illinois River and the Lake Calumet system and by 1992 was captured near the mouth of the Illinois River (Fig. 1). One of us (GLS) has collected *M. americana* annually from the upper reaches of the Illinois River drainage (RM 270.2-323.1) from 1990 through 1994. During this period, 46 specimens have been collected including several < 30 mm SL, which undoubtedly are young of the year (Mansuetti 1964). From 2 September to 4 October 1994, 10 adult and one juvenile *M.*

americana were collected from the Calumet River (RM 328-330), Cook County. In 1994, two larval (7.5 and 10.5 mm SL) *Morone* were collected from the Des Plaines River near Romeoville. Meristic features and other characteristics suggest that these two larvae represent *M. americana*, the most common *Morone* in the area; however, positive separation from the Yellow Bass (*Morone mississippiensis*) at this size is not possible. As of 1993-1994 *M. americana* reached extreme southern Illinois via the mainstem Mississippi River, with recent records from the Horseshoe Lake drainage, Alexander County.

Other than the Great Lakes, another possible source of the presence of *M. americana* in the Mississippi River is via the Missouri River as a result of introductions made into Nebraska lakes beginning in 1964 (Hergenrader and Bliss 1971, Zuerlein 1981). Cross et al. (1986) reported records from the Platte-Niobrara rivers and Hesse et al. (1982) reported the species from the middle Missouri River. However, we are unaware of any recent records of *M. americana* farther downstream in the Missouri River.

Lengths of specimens (individuals less than 70 mm SL are considered young of the year according to Marcy and Richards [1974]) captured and vouchered in research or reference collections (i.e., EA Midwest, INHS, and SIUC) indicate convincingly that *M. americana* is reproducing in Illinois waters and is almost certainly an established member of the Illinois fish fauna. The species is known to spawn in shallow fresh water over a variety of bottom types and often increases rapidly in numbers despite the presence of other established species (Scott and Crossman 1973). We predict that *M. americana* will continue to spread southward in the Mississippi River and will reach large enough population levels in Illinois to compete with native *Morone* and other species for various resources. In addition, the presence of four species of *Morone* (two native, and two nonnative) together with stockings of *Morone* hybrids in Midwest rivers (e.g., the Ohio River), is likely to complicate indentification of juvenile and subadult representatives of the genus.

In five years *M. americana* has dispersed nearly the entire length of Illinois, and represents an outstanding example of how quickly a newly-invading species can spread and become established. Only *O. mordax* has been shown to have moved more rapidly downriver in the Mississippi River basin (Mayden et al. 1987) from points of introduction in the upper Missouri River and possibly the Great Lakes.

DISCUSSION

When Forbes and Richardson (1908) published their classic work on Illinois fishes only one nonnative species was known to be established in the state, the Common Carp, *C. carpio*. By the late 1970s, 13 nonnative fish species were present in Illinois waters (Smith 1979). By 1990, 22 nonnative species (including southern invaders) were known from Illinois, although not all were documented as established at that time (Burr 1991). We add here evidence in the form of young-of-the-year and/or age class variation that circumstantially demonstrates that *C. idella*, *H. nobilis*, *M. anguillicaudatus*, *M. beryllina*, and *M. americana* are reproducing and established in Illinois waters; we predict that *H. molitrix* will become established within the next decade.

In general, nonnative species, especially those introduced into the Southwest, have had an adverse effect on native fishes (Becker 1983, Courtenay and Robins 1989); however, the feeding niches (i.e., vegetation, plankton) of the Asian carps are somewhat different than most of the fishes native to North America. In addition, all of the Asian carps reach a large size and are relatively more fecund than many native species. The widespread distribution of these species in Illinois streams makes it impractical to eradicate them from known areas of occurrence. Direct effects of introduced species on native species include: 1) elimination, 2) reduced growth and survival, 3) changes in community structure, and 4) no effect (Moyle et al. 1986). Perhaps of greatest concern are species such as *M. americana* that have spread rapidly, and which tend to become overpopulated and stunted, thereby competing for food resources and reducing the growth rates of other more desirable sportfishes (Zuerlein 1981). In fact, Zuerlein (1981) traces the history of purposeful (starting in 1964) and inadvertent introductions of *M. americana* in Nebraska and presents an alarming case for a species that has few desirable qualities in the Midwest. Early sexual development, ability to spawn in a variety of habitats, high reproductive potential, die-offs before reaching a desirable angling size, and difficulty and expense of eradication are questionable qualities in terms of human welfare, sportfishing, and native fish communities.

Of notable interest is the preponderance of nonnative species (e.g., *O. mordax*, *M. cephalus*, *M. beryllina*, and *M. americana*) that are principally euryhaline or inhabitants of marine environments. All of these species except *M. cephalus* are now established in Illinois and other Midwestern states. These ecologically labile species perhaps represent the extreme in colonizing species, with each exhibiting traits that demonstrate their tolerance for a variety of variable environmental conditions.

The source of nonnative fishes in Illinois waters is varied and perhaps more complicated than we are aware. Of the species reported here, three have dispersed after having been introduced into other states (e.g., *O. mordax*) or by recent changes in enviromental conditions (i.e., warming, drought) that have allowed their (e.g., *M. beryllina*, *M. cephalus*) movement northward. Others (e.g., *C. auratus*, *H. molitrix*), not certainly established in southern Illinois but introduced originally as food fishes or for aquaculture studies, appear to have become more widely distributed after the recent Mississippi River flooding. Still others (e.g., *C. idella*, *H. nobilis*) have become established after earlier introductions for other purposes (i.e., weed control, improvement of water quality in culture ponds). One species (*S. erythrophthalmus*) has been introduced via bait bucket and two others (*M. anguillicaudatus*, *P. brachypomus*), probably through release of aquarium stock. *M. americana* has spread rapidly from the Great Lakes to southern Illinois because of its tolerance for varying ecological conditions. The exotic carps and *C. auratus* are of some use to humans as food or for control of weeds in small water bodies, but few would argue for their desirability as sportfish. Moreover, the well documented impacts of the Common Carp (*C. carpio*) on both aquatic habitats and native species does not bode well for those concerned with further establishment of these large and ecologically aggressive cyprinids. Others (*O. mordax*, *M. cephalus*, *S. erythrophthalmus*, *M. anguillicaudatus*, *P. brachypomus*) would appear to be relatively harmless because they are either not established or are only occasional transients in Illinois waters. Only time and careful study will allow us to understand the long-term ecological effects of the established *M. americana*.

It is clear that both purposeful and unintentional introductions can lead to undesirable results, especially in terms of sportfishing, human welfare, and ecological interactions. Moyle et al. (1986) introduced the concept of the "Frankenstein Effect" suggesting that if broad scale consequences of each introduction are not considered, they may ultimately cause more problems than they solve. While it may be too early in the history of invasion of nonnative Illinois fishes to detect a demonstrable effect on native communities, studies in other parts of North America allow us to conclude that further introductions are not warranted in most bodies of water and that more targeted education is needed to prevent accidental or unintentional introductions (i.e., mixed stockings, release of aquarium pets) into Illinois.

Courtenay and Moyle (1992) provide an instructive overview of the legacy of fish introductions into the United States and note that success of introductions depends on whether they are defined mainly in terms of economics or angler satisfaction. It is not our purpose to re-review that material but only to point out that the American Fisheries Society has adopted policy statements on intentional introductions (e.g., Kohler and Courtenay 1986), yet no state seems to have adopted these policies or protocols as their policy. Li and Moyle (1993) present ecological concepts important for understanding the effects of introductions, suggest some management alternatives to introducing new species, and provide guidelines for evaluating proposed introductions. Changes in values, an expanding human population, and a decline in natural habitats provide an opportunity for reconsideration of old policies and values. Illinois could become a model for the nation by adopting a proactive and progressive set of policies and protocols for introductions. There is now considerable public concern for endangered species, maintaining water quality, preserving natural areas and biodiversity, and protecting the limited wild areas we have left in Illinois. Keeping all possible options open when considering the future of Illinois' natural resources is vital.

ACKNOWLEDGMENTS

We appreciate the field assistance of Brett J. Dunn, Ed Walsh, and the 1993-1994 SIUC ichthyology classes. Larry Vaughn apprised us of the appearance of Silver Carp in Horseshoe Lake. Don Garver, IDOC fishery biologist, brought specimens of the Bighead Carp to our attention. June McIlwain, U.S. Fish and Wildlife Service, brought two records of the Pirapatinga to our laboratory, and Leo G. Nico, National Biological Service biologist, helped in the correct identification of that species. Jim Smithson, Illinois Power Company, located the newspaper account of the Pirapatinga from Lake Baldwin. William L. Pflieger, Missouri Department of Conservation, provided a record of the Striped Mullet from the Mississippi River.

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Figure 1. Record stations and dates of capture for the White Perch (*Morone americana*) demonstrating the rapid spread of this species in Illinois from Lake Michigan to the Mississippi River in extreme southern Illinois. Numbers of individuals captured are in parentheses; range in size of specimens captured is in mm SL.