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Iowa's Waters and Fishes: A Century and a Half of Change[2]

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Settlers in Iowa found a rich and diverse fisheries resource in its creeks, rivers, and lakes. However, for nearly a century, degradation of the aquatic environments and their fishes occurred as a result of agricultural and urban development. Since the 1930's management efforts have improved the interior sport fishery resources but many nongame species have been extirpated or are imperiled in the state. Various forms of pollution and habitat alteration remain as threats to the well-being of stream and lake fishes in Iowa. The Mississippi and Missouri rivers bordering Iowa have been drastically changed by navigation improvements and other influences. At least 17 Iowa fishes may be regarded to be in danger of extirpation from these waters, and stocks of many others have been depleted. Fisheries production of the Upper Mississippi River has been relatively stable for the past several decades and is improved in some respects but that of the Missouri River has declined to relative insignificance. Efforts are presently under way to mitigate the damage caused to the fish and wildlife resources of these rivers by the navigation alterations.

INDEX DESCRIPTORS: Iowa, fishes, fisheries, endangered fish species, habitat alteration

". . . of *Fish* there can never be any scarcity. Every stream is filled with them; and among them may be found the pike, the pickerel, the catfish, the trout, and many others" (Lea 1836).

". . . we rested on clear lake two days We was so fatigued, but we had fine sport fishing. fish in abundance" (U.S. Army Dragoon Journal of 1845; Rutland 1953).

"The streams were swarming with fish of many kinds. We caught them in large numbers with hook, spear, net, seines and traps. In spring when they were going up stream, we would salt down a large barrel of them for summer use. There were pike, pickerel, bass, redhorse suckers, large blue catfish, boolponts, sunfish, eels etc." (Kegley 1936, describing life in Story Co., Iowa, in the 1870's).

So wrote two early explorers and a pioneer of the prairie about the native fishery resources of a pristine and long-vanished Iowa. A century and more after these experiences, what enormous changes have occurred in the waters and fish fauna of the state! Among the nearly 140 fish species native to Iowa, perhaps a dozen have been extirpated, and populations of many others have been decimated. By intentional and accidental introduction, at least 9 non-native fishes presently reside in Iowa waters. Still, although modified, the fisheries of Iowa remain an important natural resource, perhaps far exceeding their original value in terms of economic and recreational benefits to the state. Through management efforts, some factors previously having adverse effects on the fisheries have been ameliorated. Other problems, old and new, continue as challenges to conservation. This paper provides a summary of the recent history of change in Iowa's waters and ichthyofauna with comments on the promise for their futures.

INTERIOR WATERS AND FISHES

The pioneer period in Iowa was brief, lasting scarcely over a human generation. Yet during that time, a pattern of economic development and natural resource exploitation was established that has had lasting detrimental impacts on the aquatic environments. As the land was cleared, plowed, and drained, as streams were ditched for agricultural uses, and as urban centers flushed their sewage into waterways, deterioration of conditions for aquatic life occurred with startling rapidity. Other factors also contributed to an early decline of the state's fish fauna. By 1870, more than 1000 low-head dams, constructed for milling, navigation, and water-supply purposes, impeded the seasonal migrations of fish in interior rivers. Around 1880, the Asian carp was introduced into Iowa to be cultured as a food fish, but it quickly established wild populations and spread through warmwater streams and lakes. Although it subsequently assumed significance as a commercial and game fish, this was at the expense of the depletion of many valuable native fishes that were unable to survive in waters roiled and denuded of vegetation by carp and other rough fish that followed its invasion. Undoubtedly, unlimited fishing also took a heavy toll among local fish stocks, contributing to their demise. Early public awareness and concern for Iowa's declining fishery resource is evidenced by the first fishing regulations in 1863 and establishment of a State Fish Commission in 1874 for purposes of fish propagation, controlling harvests and construction of fishways over dams. In the 1880's, other regulations followed, establishing additional closed seasons and declaring illegal various destructive fishing techniques such as use of explosives. Unfortunately, little enforcement of these regulations was possible through the limited facilities of the State Fish Commissioner. It is equally regrettable that the earliest fisheries surveys by Meek, Call, and others were not conducted until the 1880's, nearly 50 years after settlement had begun and at a time when the resource was already considerably altered. Regarding the conditions of his day, Meek (1892) wrote: "I have been informed that many streams, formerly deep and narrow, and abounding in pickerel, bass, and catfishes, have since grown wide and shallow, while the volume of water in them varies greatly in the different seasons, and they are inhabited only by bullheads, suckers, and a few minnows." This was because: "The soil, since loosed with the plow, is much more easily washed into the streams than when it was covered with the stiff native sod. The more thorough underdraining and the surface ditches enables the water, after heavy rains, to find its way at once into the large creeks and rivers. Thus the water in the streams is muddier than formerly; in wet weather is deeper, and in dry weather is more shallow. These features, together with the fact that the rivers are becoming, to some extent, the sewers for the large cities, is a probable cause for a dimunition of some of the food fishes" (Meek 1893).

By the turn of the century, the replacement of desirable food and game fishes by ecologically tolerant rough fishes reached such proportions that the State Fish and Game Warden was authorized to grant permits for rough fish removal. Other management efforts during this period included a limited propagation and stocking program. At various times, several types of salmon and trout were introduced, but all the

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plantings failed to produce self-sustaining populations. As early as 1876, fish rescue operations were carried out in isolated flood plain pools of large rivers, the fish being liberated back to the rivers or distributed throughout the state. This practice resulted in establishing new populations of some species, especially in lakes. Fish rescue continued as a significant part of Iowa's fishery management program until the 1950's when it was abandoned in favor of expanded hatchery operations.

The environmental problems associated with agricultural and urban development only intensified during the first 3 decades after 1900. A major portion of Iowa's wetlands were drained by the end of this time (Bishop, this volume). In excess of 1000 miles of stream were eliminated through channel straightening (Bulkley 1975), and sediment constituted a serious water-quality problem over much of the state. Most major inland rivers and some lakes suffered serious, extensive sewage pollution. In the absence of fishery survey information for this period, we can only surmise that these factors had a devastating effect on Iowa's fish fauna. Especially in lakeless southern Iowa, fishing was restricted to silt-laden, polluted streams with the prospect of catching little more than hardy bullheads and catfish.

The decade of the 1930's, however, marked the beginning of the modern era of wildlife resource conservation in Iowa, under direction of the 25-Year Conservation Plan (Crane and Olcott 1933). Among the Plan's provisions for restoration of the fisheries were development of a comprehensive and continuous fisheries survey, research on fish ecology and management, improved fish cultural facilities and stocking policies, and ambitious programs of habitat improvement, land acquisition, artificial lake construction, public education, and erosion and pollution control. A systematic fishery survey was established by 1939 which culminated in publication of *Iowa Fish and Fishing* by Harlan and Speaker in 1951 (rev. ed. 1956). Research efforts were assumed both by the State Conservation Commission and the Iowa Fishery Research Unit, founded in 1941 at Iowa State College in Ames. The habitat improvement program emphasized rough fish removal, dredging of shallow silted lakes, placement of habitat structures in streams and lakes, and construction of artificial lakes. By midcentury, 15 public fishing lakes had been constructed and about 20 municipal reservoirs also provided public fishing. Major strides also were made in curbing sewage pollution during this period. By 1945, about 87% of the interior urban population was served by sewage treatment, and pollution loads in streams had fallen dramatically from levels of 15 years previous (Speaker and Bailey 1945). Despite efforts of a number of state and federal agencies, however, soil erosion off agricultural land proceeded at an accelerated rate as farming became more mechanized and increasingly utilized marginal lands and drained wetlands for cropping.

Within a decade after development of the new Iowa Fish Management Plan in 1936, many successes in restoration of the interior fishery resource could be enumerated (Speaker and Bailey 1945). Nevertheless, it also had become clear that a portion of the damage inflicted by 100 years of environmental abuse was irreparable, particularly among nongame fishes. Bailey (1956) summarized the situation as follows: ". . .Meek found many fishes in abundance that are now rare, noted some to be widespread that are now of restricted or local occurrence, and caught nearly a score that are wholly extirpated from Iowa. It is doubtful whether any other state has experienced such extensive reduction in its original fish fauna."

During the recent era, Iowa's inland fishery management program has continued to provide an improved and expanded sport fishery. Over 190 natural and artificial lakes of 10 acres or more in size support public fishing. Additionally, over 80,000 private farm ponds contribute significantly to the fishery. Seven state fish hatcheries currently produce 11 forms of game fish which are stocked for establishing populations in new or renovated waters, supplementing existing stocks, providing put-and-take and trophy fisheries, and improving the food chain. Stocking of two non-native trouts (brown and rainbow) supports most of Iowa's popular coldwater fishery. The muskellunge, once extirpated from Iowa, is again a prized game fish in several larger lakes through stocking. Licensed commercial fishing for rough fishes in a number of lakes provides economic benefits and contributes to management objectives.

Twenty-five years ago, Cleary (1956) argued that management of the state's fishery resource must also give attention to that majority of the ichthyofauna that does not have direct economic significance but which contributes importantly to ecosystem functioning and can serve as a monitor of changing environmental conditions. In the 1970's, continuing concern for the decline of all nonmanaged native flora and fauna led to legislative protection of species seriously threatened with state extirpation (Chapter 109A of the Iowa Code). A state list of endangered and threatened native fish species was compiled by the State Preserves Board (Roosa 1977) and approved by the Iowa Conservation Commission. Including species regarded as either extirpated or of undetermined status, this list totals 34 species, nearly one-quarter of all native fishes. Of these, 19 are fishes that primarily inhabit interior waters, and at least 4 other inland species seem to merit special concern (Table 1). Stream dwelling minnows contribute chiefly to this group (12 species); darters (3 species) and suckers (3 species) also are prominent. There have been no recent reported collections of 10 forms, and 5 are already regarded as extirpated. As described by Roosa (1977), a variety of factors is

Table 1. *Endangered fishes of the interior waters of Iowa.*

	Iowa Status	Neighboring State Lists
American brook lamprey	Threatened	MN,MO
Grass pickerel	Threatened	
Redside dace	Extirpated, NC	
Lake chub	Endangered, NC	IL
Gravel chub	Threatened	
Pugnose shiner	Threatened	IL,MN,WI
Ironcolor shiner	Extirpated, NC	IL
Blackchin shiner	depleted, NC	IL
Blacknose shiner	Endangered	IL,MO
Redfin shiner	depleted	
Topeka shiner	Threatened	
Ozark minnow	depleted	WI
Largescale stoneroller	depleted	
Pearl dace	Endangered	NE,SD
Lake chubsucker	Extirpated, NC	MN,MO
River redhorse	Extirpated, NC	IL,WI
Black redhorse	Endangered	MN
Starhead topminnow	Endangered, NC	WI
Plains topminnow	Endangered, NC	MO,SD
Longear sunfish	Endangered, NC	WI
Least darter	Endangered	MN
Orangethroat darter	Endangered	
Gilt darter	Extirpated, NC	IL,WI

depleted = not included on Iowa endangered fishes list but meriting special concern
NC = not collected in Iowa for at least 25 years

associated with the tenuous existence of these fishes in Iowa. On the one hand, several are distributionally peripheral to the state, being known from only one or a few sites near the state border; e.g. lake chub, pugnose shiner, pearl dace, and lake chubsucker. Most others also have been historically rare, limited to infrequently occurring habitats. Ten of the species listed in Table 1, along with brook trout and several other small native fishes, are restricted to northeastern Iowa. On the other hand, the grass pickerel, blackchin shiner, blacknose shiner, redfin shiner, and Topeka shiner formerly were widespread and have clearly suffered range reduction in Iowa. Although explanations for the decline of the depleted fishes are admittedly conjectural, such factors as increased water turbidity, siltation effects, and loss of aquatic vegetation have been commonly cited (Roosa 1977). Moreover, that most species also are regarded as imperiled in one or more neighboring states (Table 1) implies that similar environmental degradation is occurring elsewhere. Within the Corn Belt region, in general, fishes requiring cool, clear water have undergone drastic declines as agricultural practices have modified stream and lake environments, to be replaced by others, primarily of western and southern origin, which are of ecologically broader tolerances (Smith 1979).

In 1981, pollution problems continue as major threats to the well-being of Iowa's fishery resource. During the 1960's and 1970's, agricultural pesticide contamination of Iowa fish became a serious human health concern. By 1971, the public was advised to restrict eating of pesticide-contaminated fish from some lakes and rivers, and commercial fishing was prohibited in Coralville Reservoir between 1976 and 1979. Since the ban of the most highly toxic and persistent pesticides by the U.S. Environmental Protection Agency in 1975, their presence in Iowa waters and fishes has declined to levels considered acceptable for human health. Although major pesticide-caused fishkills have not been reported in Iowa, the long-term impact of these pollutants on the ichthyofauna is really not known. The embryonic and larval phases of fish development are especially susceptible to disruption by such contaminants, and chronic physiological impairments can occur throughout life. Questions about the potential adverse influences of pesticides on fish food resources also go without satisfactory answers. Since large-scale agricultural pesticide applications can be expected for many years, additional ecological research on pesticides and continuous field surveillance is clearly required.

Since the earliest Iowa fishery investigations, the manifold detrimental effects on fish of high levels of silt turbidity and sediment have been recognized. These include interference with reproductive activities, early development and feeding, habitat elimination, and transmission of toxicants and disease producing organisms. Moreover, sport fishing often is more productive and certainly more enjoyable in clearer waters. Development of soil conservation practices and restoration of riparian habitats by means that are economically feasible and compatible with other important land uses must be of high environmental priority today and in the future.

Inputs of plant nutrients from wastewater effluents and agricultural sources contribute to the eutrophic (nutrient-rich) condition of most Iowa waters. Especially in lakes, where nutrients tend to accumulate, this results in high levels of plant productivity. Excessive algal and vascular plant growth has deleterious effects on fish and fisheries in several ways. In addition to inhibiting fishing, it can significantly reduce living space for fish and interfere with predator-prey relationships, often promoting overpopulation and reduced growth of game species. Perhaps more significantly, the anaerobic decomposition of vegetative detritus is frequently responsible for summer and winter dissolved oxygen depletions, resulting in mortalities. Moreover, the blue-green algae characteristic of highly eutrophic waters release toxins upon decomposition. Such conditions may result in local extirpations of ecologically sensitive fishes with replacement by more tolerant ones. As point source nutrient inputs are gradually being controlled in Iowa, nonpoint source contributions assume greater importance in determining environmental conditions for aquatic life. Application of best land management practices has been offered as the most feasible method of reducing nonpoint source agricultural nutrient pollution, but the effectiveness of this approach remains to be determined. After extensive field testing, the Iowa Conservation Commission has recently approved use, by permit, of the herbivorous Asian grass carp as a means of biological control of excessive aquatic plant growth.

With the likelihood of future increased mining of the high-sulfur coal reserves of Iowa, there is potential for serious and long-lasting water-quality degradation by acid mine drainage. Conditions of acid mine pollution are common in streams draining past and present mining areas in southestern Iowa, and the most heavily polluted ones are devoid of fish (Nesler 1977). Without rehabilitation of abandoned mine areas and reclamation of current and future mining operations, this form of habitat destruction seems inevitable over a large portion of southern and western Iowa.

Agricultural channelization with its destructive effects on aquatic habitats continues in small streams throughout Iowa. The recent adoption of channelization guidelines by the U.S. Soil Conservation Service and enforceable regulations by the Iowa Natural Resources Council are positive steps toward the mitigation of this problem. The Council also has established minimum streamflow standards to assure flows adequate for aquatic life.

BORDER WATERS AND FISHES

The Upper Mississippi River visited by Joliet and Marquette in 1673 was a broad channel meandering among hundreds of islands, sloughs, side channels, and flood plain lakes. Its numerous shoals, rapids, rocks, and snags posed navigational problems to those early river travelers but also provided a diverse habitat for more than 80 species of fishes. Accounts of frontier exploration and travel on the river commonly mention the abundance and great size of such fishes as lake sturgeon, paddlefish, catfishes, northern pike, and buffalo.

Environmental change in the river began when efforts to maintain a commercial navigation lane were initiated in 1820 by the U.S. Army Corps of Engineers. For many years, these activities were largely limited to removal of snags and other obstructions. Authorization to establish a navigation channel 4½ ft. deep between Minneapolis and St. Louis came in 1878. Subsequently, the channel was deepened to 6 ft. and then to 8 ft. This was accomplished by dredging, placement of bank-stabilization structures and current deflectors along the main channel, and draining side channels and backwaters. Throughout this period, urban centers rapidly expanded along the banks of the river, utilizing its waters as a convenient conduit for waste disposal.

Little is known of the early development of the river's commercial fishery. But by 1876, it had apparently reached such proportions that the Fish Commissioner of Iowa advocated regulations to protect spawning fish (Carlander 1954). By the time of the first reliable compilations of catch statistics in the 1890's, the Upper Mississippi was yielding landings of 11 to 14 million pounds annually, with a major proportion derived from Iowa waters. In general order of their abundance in the catch, the principal commercial species were: buffalo and other suckers, catfishes, freshwater drum, sturgeons, paddlefish, carp, and game fishes (primarily walleye, sauger, yellow perch, white and yellow bass, sunfishes and crappies). At the same time, the rich mussel beds of the river supported a flourishing fishery and pearl button industry.

By the early 1900's, however, habitat degradation caused by the navigation improvements, and rapidly increasing erosion sediment and pollution loads had induced profound changes in the fisheries. Catches of carp rose quickly during the 1890's and soon became dominant

among a fishery shifting increasingly toward rough fishes. In an ultimately futile effort to restore the decimated mussel beds, the U.S. Bureau of Fisheries established a research and cultural station at Fairport, Iowa, in 1908. Until the abandonment of its research program in the 1930's, the station made important contributions to freshwater fisheries biology and fish culture. Future developments on the river were foretold in 1913 with completion of the large hydroelectric dam at Keokuk, Iowa. Lacking fishway facilities, it became a barrier to upstream movements of numerous commercially important migratory fishes (Coker 1929). Above the dam, higher water levels initially created extensive tracts of shallow backwaters. For a time thereafter, this expansion of habitat improved fishing for some desired species. However, the reduced current soon promoted siltation of these areas and the main body of the lake. By 1930, the once productive backwaters had virtually disappeared, having been largely converted to agricultural uses. Sport fishing became primarily limited to catfish and the now thriving carp. Likewise, the reduced commercial fishery was supported almost entirely by bottom-feeding catfish and rough fish while the mussel fishery was all but eliminated (Ellis 1931).

In 1930, Congress approved additional navigation enhancements on the Upper Mississippi, involving channel deepening to 9 ft. and construction of 25 locks and dams, 10 within the Iowa reach, for purposes of water level control. The dams thus converted the free-flowing river to a series of river "pools", each pool experiencing a sequence of habitat and fish community modification similar to that of Keokuk Lake. By 1950, commerical catches throughout the river were dominated by four groups: carp, buffalo, catfishes, and drum. Sturgeons, paddlefish, and American eel had largely disappeared from commercial landings, and taking of most game fishes was prohibited. The need for uniform fisheries regulations by the states bordering the river and for cooperative action on their shared river environmental problems led to the organization of the Upper Mississippi River Conservation Committee in 1943. The Committee has served importantly in the development and continuity of research and fishery statistics information upon which the modern state management programs are based. The success of these efforts may be measured by the increased commercial fishing activity and catches during the past quarter century. Throughout the 1960's and 1970's, the annual total Upper Mississippi landings have regularly exceeded 10 million pounds (Kline and Golden 1979a). The harvest continues to be dominated (95+%) by carp, buffalo, catfishes, and drum, but catches of the minor species generally have remained stable or have increased somewhat. Throughout the recent period, Iowa fishermen have accounted for more than 25% of the total commercial catch, pools 9 and 19 ranking first and third, respectively, in productivity.

Quantitative information on the sport fishery of the river preceding the 1940's is limited but early reports are qualitatively little different from modern records, which describe a diversified fishery of about 30 species (Kline and Golden 1979b). Since the first systematic creel surveys, the most important fishes have been (in approximate order of abundance) bluegill, crappies, drum, sauger, white bass, channel catfish, walleye, yellow perch, largemouth bass, and bullheads. During the past 20 years, catches of bluegill, crappies, and bullheads have steadily declined while those of walleye, sauger, and drum have increased. In Iowa waters, snagging of paddlefish recently has developed as a significant sport fishery, accompanying increased commercial catches. These changes probably reflect continued loss of backwater areas through siltation as well as changing fishermen attitudes toward certain species and generally increased angler mobility and access to the river. Overall harvests and catch rates appear to be little changed during this period, however.

Although the Upper Mississippi River continues as an important fishery resource of the state, at least a dozen of its indigenous fishes have substantially declined during the historical period, several to the point of local extirpation (Table 2). The lake sturgeon, formerly significant to both the sport and commercial harvests, now is exceedingly rare throughout the entire Upper Mississippi. This large and slowly maturing species probably was a victim of early overfishing. The muskellunge often was mentioned in accounts of early fishing on the river, but it now is entirely extirpated there. It too may have succumbed to overharvesting. The highly migratory skipjack herring, Alabama shad, and blue sucker have suffered extensive range reduction in the river after construction of the navigation dams that blocked their movements. Each was previously of value to the commercial fishery, and the herring was of significance as host for glochidia of a depleted mussel, the ebony shell. In addition to these, a number of little known fishes cling to a precarious Iowa existence in the Mississippi. The parasitic chestnut lamprey may have been historically uncommon in the river above Keokuk and is now known only rarely from pools 10-12. Several threatened minnows and darters are sensitive to sediment and pollution. Others may have declined because of general backwater habitat loss (Roosa 1977).

Table 2. *Endangered fishes of the large border rivers and associated lowland areas of Iowa.*

	Iowa Status	Neighboring State Lists
Mississippi River		
Chestnut lamprey	Threatened	
Alabama shad	Extirpated, NC	IL,MO
Skipjack herring	Threatened	MN
Pallid shiner	depleted	IL,MO,WI
Pugnose minnow	Undetermined	MO
Weed shiner	Threatened	IL,WI
Pirate perch	Undetermined	
Crystal darter	Undetermined, NC	IL,WI
Western sand darter	Threatened	IL
Mud darter	Threatened	WI
Bluntnose darter	Threatened	WI
Missouri River		
Pallid sturgeon	Endangered, NC	IL,MO,NE,SD
Sturgeon chub	Extirpated, NC	MO,SD
Sicklefin chub	Endangered, NC	IL,MO,SD
Silverband shiner	Endangered, NC	
Both Rivers		
Lake sturgeon	Endangered	IL,MN,MO,NE
Blue sucker	depleted	MI,WI

Since its description by Lewis and Clark as a sprawling, muddy river studded with islands and snags, the Missouri River adjacent to Iowa has undergone radical changes. As determined from time-series mapping and hydrologic studies, the natural river was characterized by periodic extreme flooding and channel instability. By the time of its first detailed mapping in 1879, the meandering river had been transformed by natural processes into a shallow and braided condition. Although structural modifications for improved navigation were initiated lower on the river as early as 1832, the reach in Iowa remained in a largely natural state until about 1930. During the following decade, realignment and deepening of the navigation channel was accomplished through dredging and placement of current and bank-control structures. During the 1950's and 1960's, the channel was deepened to its present 9 ft., and

hundreds of additional control structures were installed. The result has been the creation of a smooth, narrow, gently undulating channel flowing between armored banks. Since 1923, the length of the river in Iowa has been decreased by 18 miles, its surface area reduced by 66%, sand bar area reduced by 84%, and island area by 99% (Hallberg et al. 1979). Concomitant with the final phase of channel deepening, major flood and navigation control reservoirs were constructed on the river above Iowa. Their impact on the lower river has been to moderate seasonal flow fluctuations, to reduce somewhat the heavy sediment load, and to create a condition of hydrologic imbalance such that the river has degraded its bed by approximately 2 m in the past 10 years. In consequence of riverbed degradation, there has been parallel lowering of the river surface and draining of remaining backwater habitat. Thus, in Iowa, the controlled and channelized river now exists as a swift, narrow conduit largely devoid of channel structural diversity and connected backwaters.

Owing to its relatively harsher environmental conditions and zoogeographic history, the natural Missouri River in Iowa supported a smaller and less abundant fish fauna than the Mississippi, involving perhaps 65 mainstream species. Little information is available on the early commercial fishery, but it is likely that catfishes (blue, channel, and flathead), buffalo, shovelnose sturgeon, paddlefish, various game fishes and later, carp were important components of those harvests. As the river was modified for navigational needs, commercial fishing efforts became more difficult and less productive. Since the 1950's, total annual landings have ranged between about 40,000 and 70,000 pounds, with the catch dominated by carp, buffalo and other suckers, channel and flathead catfish, and paddlefish (Iowa Conservation Commission data). Sport fishing in the river has undergone a similar transformation. Today, angler harvests in the channelized river are mainly of carp, channel catfish, drum, sauger, goldeye, black bullhead, and crappies, in order of abundance (Groen and Schmulbach 1978).

Several Iowa endangered fishes endemic to the Missouri River basin are principally residents of the mainstream river (Table 2). The historically rare pallid sturgeon may now be suffering genetic extinction by interbreeding with the more abundant shovelnose sturgeon (Douglas C. Carlson, pers. comms). The sturgeon chub, sicklefin chub, and silverband shiner also appeared only rarely in old collections. The effects of the river's habitat modifications on Iowa populations of these species is not known, but recent extensive collecting by Schmulbach et al. (1975) and others has produced only a few specimens of pallid sturgeon and silverband shiner. Interestingly, the Iowa threatened skipjack herring, excluded from the Upper Mississippi by dams, has invaded the Missouri since stabilization of the river's flow.

The future of Iowa's two border rivers and their fishery resources continues to hinge on the rivers' economic development activities. Increased utilization of river water for industrial, municipal, and agricultural purposes is a certainty, demanding vigilant environmental monitoring and rigorous enforcement of water-quality standards established for protection of aquatic life. Proposals have been considered repeatedly to deepen the Upper Mississippi navigation channel to 12 ft. In response to widespread concern for the environmental impacts of such a project, Congress, in P.L. 95-502, recently (1978) prohibited further construction activity designed to expand the navigational capacity of the river's channel, locks and dams without its specific authorization. It further directed the Upper Mississippi River Basin Commission to complete by Jan. 1, 1982, a comprehensive master plan for management of the river and its major tributaries that contain commercial navigation channels. In developing the plan, the Commission is required to conduct appropriate studies to determine the ecological impacts of present and any projected expansion of navigation capacity on the fish and wildlife, water quality, wilderness, and public recreational opportunities of the rivers. Moreover, the plan must recommend specific measures to prevent or minimize damage to fish and wildlife under these circumstances. For a number of years, the Army Corps of Engineers has been investigating the feasibility of mitigating losses of fish and wildlife resources that have occurred in both the Upper Mississippi and Missouri rivers as a result of navigation alterations. In compliance with the Fish and Wildlife Coordination Act of 1958 (P.L. 85-624), the Corps recently prepared a draft mitigation plan for the Missouri River. The plan includes four alternatives for aquatic and terrestrial habitat restoration, with total costs for a 100-year project estimated at $17,600,000 for the most modest alternative to $2,178,900,000 for an alternative recommended by the U.S. Fish and Wildlife Service. These efforts provide encouragement for believing that, after a century and a half of degradation, the biological integrity of Iowa's two great rivers is largely restorable.

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APPENDIX

A List of the Native and Introduced [I] Fishes of Iowa

Petromyzontidae - lampreys

Ichthyomyzon castaneus Girard - chestnut lamprey
Ichthyomyzon unicuspis Hubbs & Trautman - silver lamprey
Lampetra appendix (De Kay) - American brook lamprey

Acipenseridae - sturgeons

Acipenser fulvescens Rafinesque - lake sturgeon
Scaphirhynchus albus (Forbes & Richardson) - pallid sturgeon
Scaphirhynchus platorynchus (Rafinesque) - shovelnose sturgeon

Polyodontidae - paddlefishes

Polyodon spathula (Walbaum) - paddlefish

Lepisosteidae - gars

Lepisosteus osseus (Linnaeus) - longnose gar
Lepisosteus platostomus Rafinesque - shortnose gar

Amiidae - bowfins

Amia calva Linnaeus - bowfin

Anguillidae - freshwater eels

Anguilla rostrata (Lesueur) - American eel

Clupeidae - herrings

Alosa alabamae Jordan & Evermann - Alabama shad
Alosa chrysochloris (Rafinesque) - skipjack herring
Dorosoma cepedianum (Lesueur) - gizzard shad

Hiodontidae - mooneyes

Hiodon alosoides (Rafinesque) - goldeye
Hiodon tergisus Lesueur - mooneye

Salmonidae - trouts

Salmo gairdneri Richardson - rainbow trout [I]
Salmo trutta Linnaeus - brown trout [I]
Salvelinus fontinalis (Mitchill) - brook trout

Umbridae - mudminnows

Umbra limi (Kirtland) - central mudminnow

Esocidae - pikes

Esox americanus vermiculatus Lesueur - grass pickerel
Esox lucius Linnaeus - northern pike
Esox masquinongy Mitchill - muskellunge

Cyprinidae - minnows

Campostoma anomalum pullum (Agassiz) - central stoneroller
Campostoma oligolepis Hubbs & Greene - largescale stoneroller
Carassius auratus (Linnaeus) - goldfish [I]
Chrosomus erythrogaster Rafinesque - southern redbelly dace
Clinostomus elongatus (Kirtland) - redside dace
Couesius plumbeus (Agassiz) - lake chub
Ctenopharyngodon idella (Valenciennes) - grass carp [I]
Cyprinus carpio Linnaeus - carp [I]
Dionda nubila (Forbes) - Ozark minnow
Hybognathus argyritis Girard - western silvery minnow
Hybognathus hankinsoni Hubbs - brassy minnow
Hybognathus n. nuchalis Agassiz - central silvery minnow
Hybognathus placitus Girard - plains minnow
Hybopsis aestivalis (Girard) - speckled chub
Hybopsis gelida (Girard) - sturgeon chub
Hybopsis g. gracilis (Richardson) - flathead chub
Hybopsis meeki Jordan & Evermann - sicklefin chub
Hybopsis storeriana (Kirtland) - silver chub
Hybopsis x-punctata Hubbs & Crowe - gravel chub
Nocomis biguttatus (Kirtland) - hornyhead chub
Notemigonus crysoleucas (Mitchill) - golden shiner
Notropis a. amnis Hubbs & Greene - northern pallid shiner
Notropis anogenus Forbes - pugnose shiner
Notropis atherinoides Rafinesque - emerald shiner
Notropis blennius (Girard) - river shiner
Notropis buchanani Meek - ghost shiner
Notropis chalybaeus (Cope) - ironcolor shiner
Notropis c. cornutus (Mitchill) - northern common shiner
Notropis d. dorsalis (Agassiz) - bigmouth shiner
Notropis heterodon (Cope) - blackchin shiner
Notropis heterolepis Eigenmann & Eigenmann - blacknose shiner
Notropis hudsonius (Clinton) -spottail shiner
Notropis lutrensis (Baird & Girard) - red shiner
Notropis rubellus (Agassiz) - rosyface shiner
Notropis shumardi (Girard) - silverband shiner
Notropis spilopterus hypsisomatus Gibbs - western spotfin shiner
Notropis stramineus missuriensis (Cope) - plains sand shiner
Notropis s. stramineus (Cope) - eastern sand shiner
Notropis texanus (Girard) - weed shiner
Notropis topeka Gilbert - Topeka shiner
Notropis umbratilis cyanocephalus (Copeland) - eastern redfin shiner
Notropis u. umbratilis (Girard) - western redfin shiner
Notropis v. volucellus (Cope) - northern mimic shiner
Notropis volucellus wickliffi Trautman - channel mimic shiner
Opsopoeodus emiliae Hay - pugnose minnow
Phenacobius mirabilis (Girard) - suckermouth minnow
Pimephales notatus (Rafinesque) - bluntnose minnow
Pimephales promelas Rafinesque - fathead minnow
Pimephales vigilax perspicuus (Girard) - bullhead minnow
Rhinichthys atratulus meleagris Agassiz - western blacknose dace
Rhinichthys cataractae (Valenciennes) - longnose dace
Semotilus atromaculatus (Mitchill) - creek chub
Semotilus margarita nachtriebi (Cox) - northern pearl dace

Catostomidae - suckers

Carpiodes c. carpio (Rafinesque) - northern river carpsucker
Carpiodes cyprinus (Lesueur) - quillback
Carpiodes velifer (Rafinesque) - highfin carpsucker
Catostomus commersoni (Lacepede) - white sucker
Cycleptus elongatus (Lesueur) - blue sucker
Erimyzon sucetta (Lacepede) - lake chubsucker
Hypentelium nigricans (Lesueur) - northern hog sucker
Ictiobus bubalus (Rafinesque) - smallmouth buffalo
Ictiobus cyprinellus (Valenciennes) - bigmouth buffalo
Ictiobus niger (Rafinesque) - black buffalo
Minytrema melanops (Rafinesque) - spotted sucker
Moxostoma anisurum (Rafinesque) - silver redhorse
Moxostoma carinatum (Cope) - river redhorse
Moxostoma duquesnei (Lesueur) - black redhorse

Moxostoma erythrurum (Rafinesque) - golden redhorse
Moxostoma m. macrolepidotum (Lesueur) - shorthead redhorse

Ictaluridae - freshwater catfishes
Ictalurus f. furcatus (Lesueur) - blue catfish
Ictalurus melas (Rafinesque) - black bullhead
Ictalurus natalis (Lesueur) - yellow bullhead
Ictalurus nebulosus (Lesueur) - brown bullhead
Noturus exilis Nelson - slender madtom
Noturus flavus Rafinesque - stonecat
Noturus gyrinus (Mitchill) - tadpole madtom
Pylodictus olivaris (Rafinesque) - flathead catfish

Aphredoderidae - pirate perches
Aphredoderus sayanus (Gilliams) - pirate perch

Percopsidae - trout-perches
Percopsis omiscomaycus (Walbaum) - trout-perch

Gadidae - codfishes
Lota lota (Linnaeus) - burbot

Cyprinodontidae - killifishes
Fundulus diaphanus menona Jordan & Copeland - western banded killifish
Fundulus dispar (Agassiz) - starhead topminnow
Fundulus notatus (Rafinesque) - blackstripe topminnow
Fundulus sciadicus Cope - plains topminnow

Poeciliidae - livebearers
Gambusia a. affinis (Baird & Girard) - western mosquitofish [I?]

Atherinidae - silversides
Labidesthes sicculus (Cope) - brook silverside

Gasterosteidae - sticklebacks
Culaea inconstans (Kirtland) - brook stickleback

Percichthyidae - temperate basses
Morone chrysops (Rafinesque) - white bass
Morone mississippiensis Jordan & Eigenmann - yellow bass
Morone saxatilis (Walbaum) - striped bass [I]

Centrarchidae - sunfishes
Ambloplites r. rupestris (Rafinesque) - northern rock bass
Lepomis cyanellus Rafinesque - green sunfish
Lepomis gibbosus (Linnaeus) - pumpkinseed
Lepomis gulosus (Cuvier) - warmouth
Lepomis humilis (Girard) - orangespotted sunfish
Lepomis m. macrochirus Rafinesque - bluegill
Lepomis megalotis (Rafinesque) - longear sunfish
Lepomis microlophus (Gunther) - redear sunfish [I]
Micropterus dolomieui Lacepede - smallmouth bass
Micropterus punctulatus (Rafinesque) - spotted bass [I]
Micropterus s. salmoides (Lacepede) - largemouth bass
Pomoxis annularis Rafinesque - white crappie
Pomoxis nigromaculatus (Lesueur) - black crappie

Percidae - perches
Ammocrypta asprella (Jordan) - crystal darter
Ammocrypta clara Jordan & Meek - western sand darter
Etheostoma asprigene (Forbes) - mud darter
Etheostoma c. caeruleum Storer - rainbow darter
Etheostoma chlorosomum (Hay) - bluntnose darter
Etheostoma exile (Girard) - Iowa darter
Etheostoma flabellare lineolatum (Agassiz) - striped fantail darter
Etheostoma microperca Jordan & Gilbert - least darter
Etheostoma nigrum Rafinesque - johnny darter
Etheostoma s. spectabile (Agassiz) - northern orangethroat darter
Perca flavescens (Mitchill) - yellow perch
Percina caprodes semifasciata (DeKay) - northern logperch
Percina e. evides (Jordan & Copeland) - northern gilt darter
Percina maculata (Girard) - blackside darter
Percina phoxocephala (Nelson) - slenderhead darter
Percina shumardi (Girard) - river darter
Stizostedion canadense (Smith) - sauger
Stizostedion v. vitreum (Mitchill) - walleye

Sciaenidae - drums
Aplodinotus grunniens Rafinesque - freshwater drum

Cottidae - sculpins
Cottus bairdi Girard - mottled sculpin
Cottus cognatus Richardson - slimy sculpin