ILLINOIS
NATURAL HISTORY
SURVEY

RECENT TRENDS IN THE ILLINOIS RIVER INDICATED BY FISH POPULATIONS

Submitted as part of the Flowing Water Ecosystems Section in the
Critical Trends Assessment Project CTA1

Center for Aquatic Ecology

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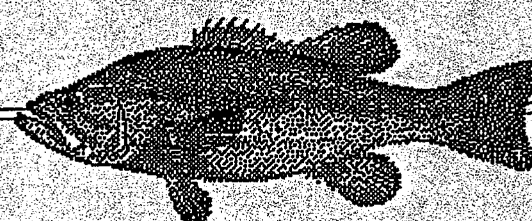

Aquatic Ecology Technical Report 93/16

DISCLAIMER

The findings, conclusions, and views expressed herein are those of the researchers and should not be considered as the official position of the United States Fish and Wildlife Service, the Illinois Department of Energy and Natural Resources, or the Illinois Department of Conservation.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Recent Trends in the Illinois River Indicated by Fish Populations

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BACKGROUND

The Illinois River belongs to a world class of large river-floodplain ecosystems, where biological productivity (including fish yield) is enhanced by annual floodpulses that advance and retreat over the floodplain and temporarily expand backwaters and floodplain lakes (Junk et al. 1989; Sparks et al. 1990; Sparks 1992). The expanded aquatic habitats are utilized as feeding areas by migratory birds and as breeding areas and nurseries by fish and other aquatic life. The Illinois River today is the largest river (in terms of water flow) contained mostly within the state, and its fish populations reflect urban influences from the state's largest metropolitan area (the Chicago-Joliet area) as well as effects of land use practices in the corn belt that runs across the middle of the state.

The river is divided into 5 reaches by navigation dams, including the Alton Dam (Dam 26) on the Upper Mississippi River which influences the lower 80 miles of the Illinois River (Fig. 1). These five reaches in turn fall into three major sections, defined by the natural physiography of the river and by the degree and nature of human alterations. The Dresden, Marseilles, and Starved Rock reaches together form the upper Illinois River, characterized by a geologically young channel with a relatively narrow floodplain between rocky bluffs. This section has been heavily influenced historically by effluents from the Chicago-Joliet area. The La Grange and Peoria reaches comprise the middle river. Here the river occupies a broad floodplain (2 to 5 miles wide) created by the ancestral Mississippi and Ohio rivers. Approximately half of the floodplain and the natural backwaters and lakes remain along this section. In contrast, most of the floodplain and backwaters have been drained in the lower river (the Alton reach), and the river channel runs between two levees until it nears the confluence with the Upper Mississippi River.

STRESSES

Major historical stresses on the ecosystem include: (1) drainage of wetlands and channelization of tributaries in the drainage basin, mostly in the late 1800s, but continuing to the present; (2) the diversion of Chicago sewage and industrial effluent from Lake Michigan to the Illinois River, via a system of waterways, starting in a major way in 1900; (3) leveeing and draining of half the floodplain in the 1920s, primarily for agriculture; (4) completion of the federal 9-foot navigation project in the 1930s; (5) intensification of agriculture in the 1950s, resulting from the shift from small grains, orchards and pastures to row crops, and introduction of practices such as fall plowing and use of pesticides and chemical fertilizers; and (6) development of an industrial corridor (chemical manufacturing, petroleum refining, and storage of agricultural chemicals) in the 1950s along the upper river and its Des Plaines tributary in the vicinity of Joliet. Upland drainage and channelization of tributaries probably increased the rate of delivery of water, sediment, and pollutants to the main river. Diversion of sewage and Lake Michigan water raised mean water levels, caused the less flood tolerant trees to die back on the floodplain, and eventually degraded water and sediment quality (Mills et al. 1966). Drainage projects on the floodplain reduced fish and wildlife habitat and the capacity of the floodplain to convey or store flood water and concentrated sedimentation in the areas that remained open to the river. The navigation dams permanently inundated portions of the floodplain, so the soils do not dry and compact as they once did during low river stages in midsummer (Bayley 1991). Also, the wind fetch was greater on the expanded lakes and backwaters, so the heights of wind-driven waves increased and thereby increased resuspension of the unconsolidated sediments. The improved navigation system stimulated boat traffic, that also generated waves which resuspended sediments and contributed to bank erosion. Intensification of agriculture, coupled with stream channelization and removal of riparian vegetation, increased the rate at which water and sediments, and chemicals associated with them, were delivered to the river. The expansion of chemical handling and manufacturing on the upper river increased the risk of both chronic pollution and spills.

RESPONSE OF FISH POPULATIONS TO RECENT STRESSES

<u>The Long Term Electrofishing Survey.</u> The fish populations of the Illinois River have been surveyed annually since 1957, except for a few years when no funding was available or sampling could not be conducted because the river was in flood. The sampling is conducted at 28 permanent locations in the fall, using an electrofishing boat, when water levels are maintained at stable, low elevations by the navigation dams (Fig. 1). Two stations are located in the Upper Mississippi River, near the confluence with

the Illinois, for comparison (Fig. 1). The entire data set has only recently been transcribed to computer disks, and is still being verified against the original field data sheets. Although comparisons of the occurrence and general abundance of fishes can be made reliably across all the years (Tables 1-3), other comparisons are based on two years, 1963 and 1992, for which data are fully verified. We believe these two years are broadly representative of the condition of fish populations in the Illinois River at the beginning of the survey and in the most recent 5 years.

Species Composition and Abundance. A total of 91 species of fishes from 18 families, and five hybrids, have been collected during the electrofishing survey from 1957 to 1992. Over the entire period, just five species dominated the upper river, with the introduced goldfish and carp ranking first and second in abundance (Table 1 and Fig. 2). In recent years however, native species have returned to the upper river, and the electrofishing catch is dominated by native minnows, green sunfish, and gizzard shad (Fig. 2). Carp now rank seventh in abundance (5.3% of the catch), and native fishes such as smallmouth and largemouth bass and bluegill sunfish comprise 3 to 4.6% of the catch (Fig. 2). Carp and goldfish are more tolerant than most native species of the low oxygen levels and toxic materials associated with heavy pollution loads, and their populations often expand in the absence of pollution-intolerant predators (e.g., the basses) (Lubinski and Sparks 1981). The change to a more balanced fish community dominated by native species reflects improvements in water quality, as corroborated by a decline since 1975 in the toxicity attributable to ammonia, which is associated with sewage effluents (Fig. 3). Another indication of improvement was the collection, independent of the electrofishing survey, of three state endangered fishes in the upper river in the period 1987-89: the pallid shiner, river redhorse, and greater redhorse (Page et al. 1992). In contrast to dominance by only five species in the upper river, 12 species were regularly abundant in the middle river and 10 in the lower river during most of the 35-year period covered by the electrofishing (Tables 2 and 3). The common carp ranked first in abundance in the lower river and second in the middle river in 1963, but was superseded by the bluegill by 1992 (Figs. 4 and 5). In the lower river, largemouth bass ranked fourth in abundance, after gizzard shad and carp, and comprised 9% of the catch (Fig. 5).

Some species that were once common are now virtually absent (Starrett 1971; Sparks 1977; INHS unpublished data). The yellow bass, northern pike, and black buffalo use flooded terrestrial or aquatic vegetation for spawning and may have declined because of alterations in the floodpulse or because of the loss of aquatic plants and general deterioration of shallow backwaters due to excessive sedimentation.

External Abnormalities. The incidence of external abnormalities (eroded fins, sores) in the fish has declined markedly between 1963 and 1992, indicating a general improvement in water quality. However, abnormalities occur more frequently in fishes that contact bottom sediments (catfish, carp) than in fish that occupy the water column (bass, bluegill), indicating that there are pollutants or pathogens associated with the sediments (Fig. 6). Also, the incidence of abnormalities increased in the upstream direction in both 1963 and 1992, implicating the Chicago-Joliet area as the source of whatever causes the abnormalities.

Body Condition. Fish biologists use a relative weight index (Wr) to indicate the general condition of fish. A value of one indicates that the weight of the fish in relation to its length is comparable to the top quartile of the fish that have been sampled in the same geographic region. A value below one indicates that the fish is underweight, and may not be growing well. In general, fish in the Illinois River that feed in the water column, such as bluegill, appear to be in good body condition, whereas fish that feed on the bottom, such as carp, are in relatively poor condition (Table 4). Sparks (1984) and Starrett (1971) related the poor condition of bottom-feeding fishes to the lack of invertebrates (fingernail clams, aquatic worms and insects) on the bottom of the river. The paucity of bottom-dwelling invertebrates was in turn linked to the occurrence of toxic levels of ammonia in the sediments (Fig. 7). Sediment toxicity increased upstream, implicating the Chicago area as the likely source.

Summary of Trends and Current Status. The relatively poor body condition of bottom-feeding fishes and the relatively high incidence of sores and eroded fins in fish that contact the bottom of the river indicates lingering problem with sediments. A shift from dominance by goldfish and carp to a mixed community with substantial representation of native species, including sport fishes, indicates a general improvement in the water quality of the Illinois River. In addition to the intrinsic value of conserving and restoring native aquatic species in the Illinois River, there are recreational and economic benefits as well. As a result of improvements in water quality and fish populations, the river currently provides 2 million angling-days per year, valued at $40 million annually, based on 1989 figures (Conlin 1991). Sauger populations in the upper river and bass populations in the middle and lower river now support nationally-ranked tournaments that are important to local and regional economies. Peoria, for example, will host a 1993 Bassmaster Superstars tournament, with the option to host it again in 1994 and 1995. Marketing studies indicate the Superstars tournament brings $6-8 million to the host city in expenditures by competing anglers, spectators, and news media, and the publicity boosts interest in outdoor recreation at the host site even after the tournament (Conlin 1991; Mr. Jack

Ayersman, outdoor writer for the Peoria Journal Star, personal communication).

PROGNOSIS

Despite the change to a better balanced fish community in the Illinois River over the last 30 years, with native species gaining in dominance over introduced species, problems remain. In addition to sediment quality, these include introduction of additional non-native species, chemical contamination of fish, lack of critical information on fish and fisheries, general habitat deterioration and diminishment of the floodpulse, and lack of a concept of what a river-floodplain ecosystem is, as a basis and guide for management and restoration.

Non-native species. It is ironic that improvements in waste treatment in the Chicago area lower the pollution barrier that once kept non-native species introduced to the Great Lakes from invading the entire Mississippi drainage via the man-made link to the Illinois River. The latest introduction is the European zebra mussel, first reported in the Illinois River in June 1991, now found throughout the Illinois River and at scattered locations in the Upper Mississippi, Ohio, and Tennessee rivers (Sparks and Marsden 1991; Sparks 1991). This mussel is capable of reaching densities of thousands per square yard and could have indirect effects on fish populations by altering the base of the food chain and smothering native mussel beds that some fishes use as spawning substrates. The white perch (originally from the Atlantic coast) has invaded the Illinois River from the Great Lakes within the last two years and the European river ruffe (a small fish) is likely to follow soon. Invaders from the Mississippi include the Asiatic clam, Corbicula, which is likely to be followed by the grass carp and the bighead carp, also from Asia. The Asiatic clam arrived in 1971.

Chemical Contamination of Fish. While fish community changes provide indirect evidence that water quality has improved, sediments in some areas, especially on the upper river, contain elevated levels of toxic substances such as heavy metals and synthetic organic chemicals (Essig 1991; Illinois Environmental Protection Agency 1992), which can accumulate in fish tissues from direct contact with sediments or be magnified in concentration through the food chain from sediments to benthic invertebrates to invertebrate-feeding fishes. Fish consumption advisories are in effect for the upper river and the middle river to the Peoria Dam for bottom-feeding fishes such as freshwater drum, channel catfish, smallmouth buffalo, and carp over 15 inches (38 cm) (Illinois Department of Conservation 1993). The persistent nature of the toxicants makes this problem particularly intractable.

Lack of Critical Information on Fish and Fisheries. As encouraging as the redevelopment of the Illinois River sport fishery is, there is too little information available to manage and regulate this fishery. No creel surveys have been done to determine how many fish are being harvested. The effects of moving several hundred of the largest bass in the La Grange reach of the river upstream, through the lock and dam into the Peoria reach is not known, yet this is what happens with each major bass fishing tournament held at Peoria, because most of the fish are caught in the La Grange reach and released, after weighing, in the Peoria reach. The nationally-ranked tournaments and local fishing may be based on just a few year-classes of bass and sauger, and the number of large fish may dwindle soon, unless the critical spawning and wintering habitats and conditions can be identified and preserved. Also, the population of large fish may be quite small, but the fish are concentrated and easily caught during low water levels because they are forced out of backwaters made shallow by excessive sedimentation. If this is the case, then length restrictions and catch-and-release regulations would help maintain the supply of large fish, and restoration of backwaters would help increase the supply.

Even less is known about the non-game species and endangered species, so the most prudent course here is to restore, to the extent possible, the natural habitats and floodpulse that maintained these species prior to disturbance. More will be said about this approach below.

Habitat Deterioration. Although the black basses, sunfishes, and crappies (Family Centrarchidae) are responding favorably to improvements in chemical water quality, particularly in the upper river, further improvements in the middle river and lower river may be limited by continuing heavy sediment loads and deterioration of backwater habitats. Suspended sediment concentrations have decreased over the past 15 to 20 years (late 1970's to late 1980's) in the Upper Mississippi River but have not changed significantly in the Illinois River (Gaugush 1993; Gaugush 1992). Suspended sediment not only reduces the visibility sight predators need to find their food (and fishermen's lures), it reduces the amount of food as well (Vinyard and O'Brien 1976; Buck 1956). The centrarchids also have complex reproductive and social behaviors that depend on visual cues, and their eggs and larvae are susceptible to smothering with sediment or predation if the guardian male cannot see and defend them. The recovery of many other species (e.g., yellow bass, northern pike, black buffalo, and several species of minnows and darters) likewise is limited by excessive turbidity, unstable bottoms, and absence of aquatic vegetation.

Lack of an Organizing Concept for Management and Restoration. Unfortunately, the current remedies for habitat deterioration may be ineffective and may create other problems for aquatic organisms because the remedies are not founded on a holistic understanding of the river-floodplain ecosystem. There currently are nine multimillion-dollar Habitat Rehabilitation and Enhancement Projects in various stages of design or construction on the Illinois River, all part of the Environmental Management Program for the Upper Mississippi River and Illinois River conducted by the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, and the five states of the Upper Mississippi River Basin, including Illinois. There are many aspects to these large, complex projects, but most involve keeping sediment-laden river water out of floodplain impoundments to the maximum extent possible. These techniques are expected to encourage the growth of aquatic plants in the clear water behind levees or moist soil plants in impoundments that are drawn down to expose mudflats. While these measures will probably benefit ducks and geese, and fish that are stocked in the impoundments, the ecosystem functions of flood storage and conveyance and use by migratory fishes will not be restored. There are considerable economic costs associated with replacing the functions once provided by the natural floodpulse of the river with human control (construction and maintenance of levees, operation of pumps and gates, production of fish in hatcheries for stocking in floodplain impoundments). Also, it is unlikely that the artificially-maintained impoundments will provide the conditions necessary for maintenance of all the species of plants and animals that occurred in the natural river-floodplain ecosystem.

An ecosystem-based perspective would lead to several alternative approaches. First, the river would be recognized as a product of its drainage basin. The tributary basins that currently contribute the most sediments to the river would be identified and prioritized for erosion control and bank stabilization, with most attention going to tributary segments and subbasins that in turn yield the most sediment. Erosion control would focus on the near-stream environment. Second, the floodpulse would be recognized as the primary driving force responsible for the past biological productivity of the river. This recognition would lead to a long-term plan to restore both the floodplain and the floodpulse, although existing levees might be used in the interim to keep river water out until the erosion control measures in the basin were effective in reducing sediment loads. The function of the low-water part of the floodpulse in drying and compacting floodplain soils would be recognized and allowed to occur. Adoption of such an ecosystem-based approach is likely to more effective and less costly in the long run than the current approach of compartmentalizing the floodplain and excluding the river.

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FIGURES AND TABLES

Figure 1. Locations of 28 electrofishing stations along the Illinois Waterway and Mississippi River. Stations 27 and 28 are on the Mississippi River, just below the confluence with the Illinois River. (Data from stations 27 and 28 are not used in the following analyses because data have been gathered for only a few most recent years. Future analyses will, however, use data from these stations as representing control sites [i.e., being least impacted by pollution from the Chicago-Joliet area], for comparison with Illinois Waterway data.) Stations 1 and 2 are on the Des Plaines River. The rest of the stations are on the Illinois River. The Illinois Waterway is divided into reaches defined by navigation dams. The Alton Dam on the Mississippi River also maintains water depths for navigation on the lower 80 miles of the Illinois River. In upstream order, the other dams and the reaches they control are: La Grange, Peoria, Starved Rock, Marseilles, and Dresden. The reaches can be grouped based upon the amount of aquatic habitat (side channels, backwaters, and floodplain lakes) available per unit length of river as follows (data from Gilbertson and Kelly 1981):

Reach	Aquatic Habitat (ha/km)	Aquatic Habitat (acres/mi)
Upper River		
Dresden	39	153
Marseilles	12	46
Starved Rock	38	152
Middle River		
Peoria	108	425
La Grange	85	334
Lower River		
Alton	40	157

The upper river flows through a much narrower valley than the other sections and has the least amount of aquatic habitat, due to a different geologic history than the rest of the river. The middle river has the most aquatic habitat, while the lower river has had most of its floodplain aquatic habitat converted to agriculture, and is now more similar to the upper river in terms of available floodplain habitat. The gradient in the upper river is 1 to 2 feet per mile (200 to 400 cm/km), while the gradient in the middle and lower sections is only 0.1 to 0.2 foot per mile (20 to 40 cm/km).

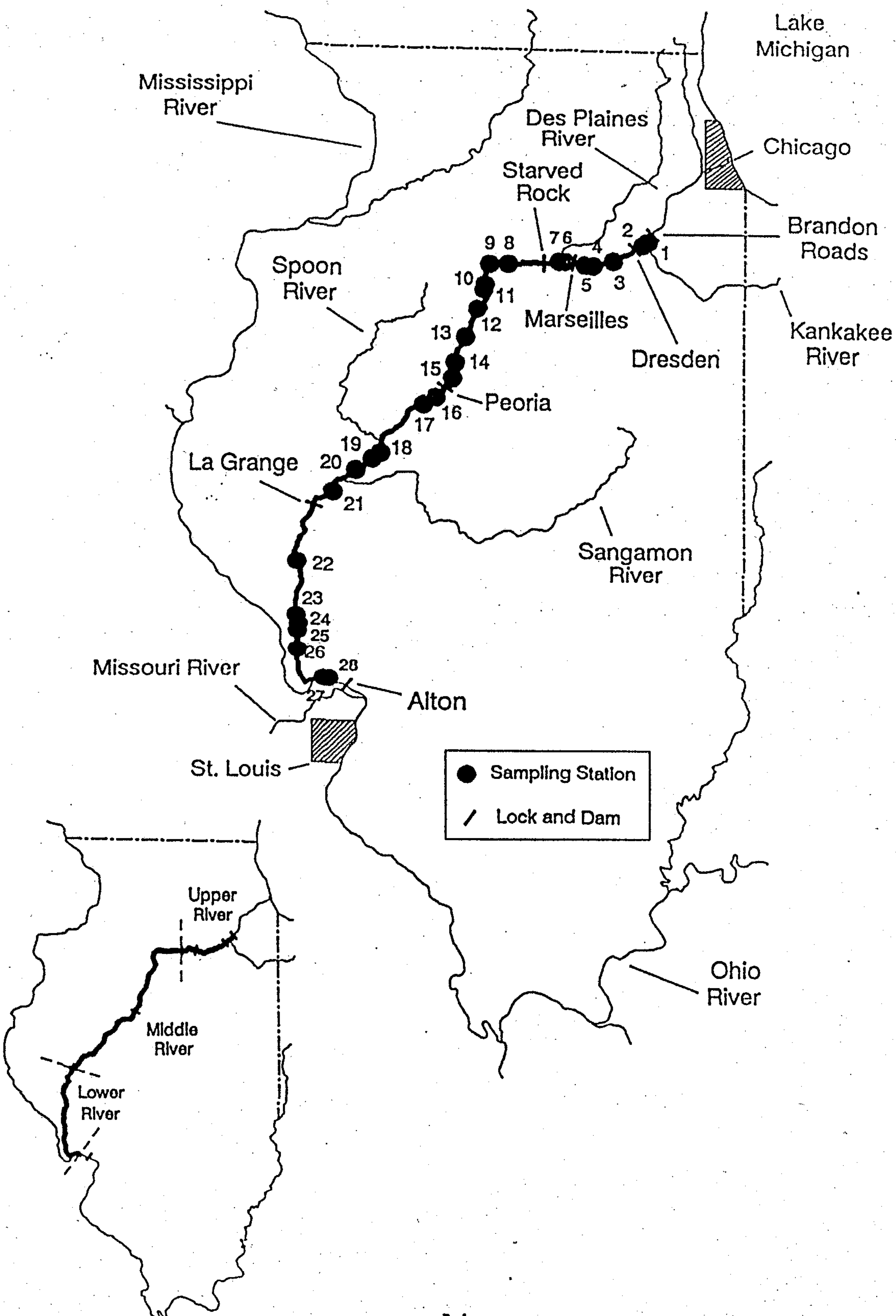
Lake Michigan
Mississippi River
Des Plaines River
Chicago
Starved Rock
Brandon Roads
Spoon River
Marseilles
Dresden
Kankakee River
Peoria
La Grange
Sangamon River
Missouri River
Alton
St. Louis
Ohio River
Sampling Station
Lock and Dam
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
Upper River
Middle River
Lower River

Figure 2. Percentages of catches by species for the upper Illinois Waterway, for 1963 and 1992, based on number of individuals collected per hour of electrofishing. In 1963, goldfish, a non-native species, accounted for almost one third of all fish collected per hour, followed by carp (also a non-native), emerald shiner, and gizzard shad. In 1963, these four pollution-tolerant species accounted for 95.8% of all individuals collected per hour. In contrast, in 1992, 13 species accounted for approximately 95.4% all fish collected per hour, and goldfish were collected in insignificant numbers, while carp were reduced to a minor component. In 1992, pollution-sensitive centrarchid species (e.g., largemouth and smallmouth bass, bluegill) made up substantial portions of catches; in addition, minnow species (e.g., emerald shiner, sand shiner, bluntnose minnow), important as a forage base for piscivorous fishes, showed a higher diversity than in 1963. Species are arranged in descending order of relative abundance in a clockwise direction and are labeled separately until approximately 95% of the pie is filled.

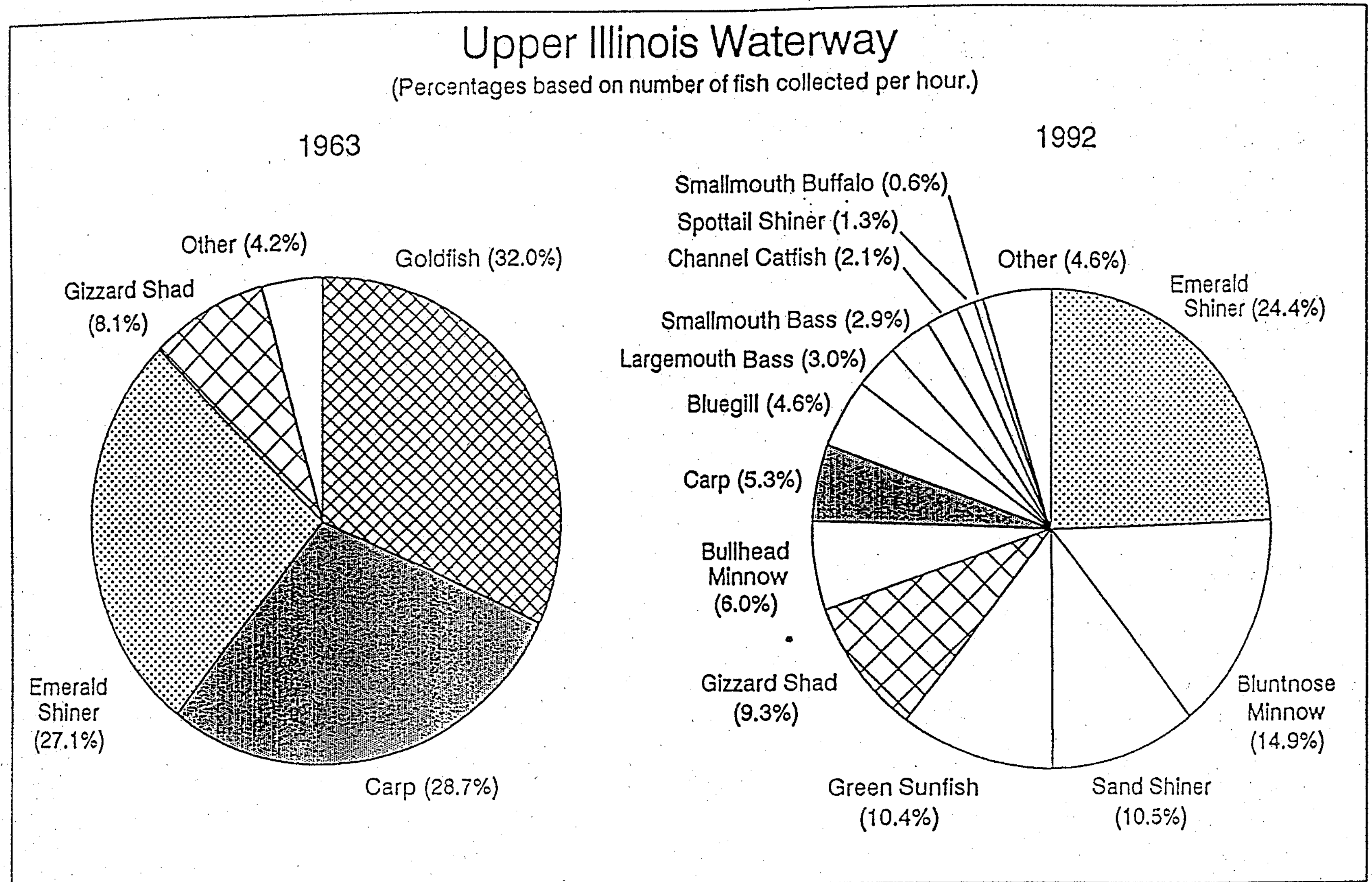
Upper Illinois Waterway
(Percentages based on number of fish collected per hour.)
1963
Other (4.2%)
Goldfish (32.0%)
Gizzard Shad (8.1%)
Emerald Shiner (27.1%)
Carp (28.7%)
1992
Smallmouth Buffalo (0.6%)
Spottail Shiner (1.3%)
Channel Catfish (2.1%)
Other (4.6%)
Emerald Shiner (24.4%)
Smallmouth Bass (2.9%)
Largemouth Bass (3.0%)
Bluegill (4.6%)
Carp (5.3%)
Bullhead Minnow (6.0%)
Gizzard Shad (9.3%)
Bluntnose Minnow (14.9%)
Green Sunfish (10.4%)
Sand Shiner (10.5%)

Figure 3. Mean Bluegill toxicity index (BTI) calculated for 1975 (16 stations) and 1990 (66 stations). The BTI was developed by Lubinski et al. (1974) and can be used to compare the relative toxicities of different substances to a reference organism, the bluegill. Calculation of the BTI requires values for pH, water temperature, dissolved oxygen concentration, fish weight, and concentration of the toxicant (data from Illinois Environmental Protection Agency 1976; Richards et al. 1991; Patterson Schafer, Inc. 1991; Polls et al. 1991a; Polls et al. 1991b). A BTI of 1.0 is defined as lethal to 50% of the bluegills exposed for 96 hr. Furthermore, experience has shown a BTI of 0.2 marks a transition state above which bluegill-largemouth bass communities change to a carp-dominated community (BTI > 0.2) (Lubinski and Sparks 1981). Although there was a substantial decline in ammonia toxicity between 1975 and 1990, the trend of increased toxicity toward the Chicago area was still evident in 1990.

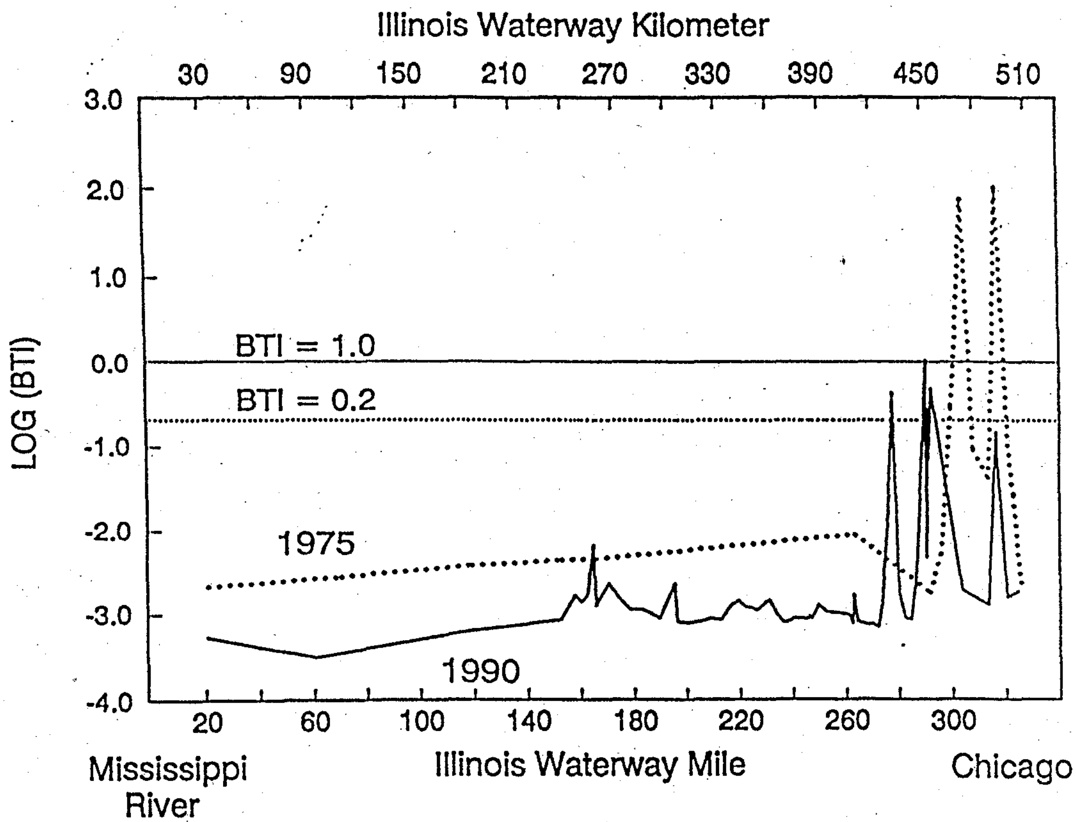
Illinois Waterway Kilometer
30
90
150
210
270
330
390
450
510
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
LOG (BTI)
BTI = 1.0
BTI = 0.2
1975
1990
20
60
100
140
180
220
260
300
Mississippi River
Illinois Waterway Mile
Chicago

Figure 4. Percentages of catches by species for the middle Illinois Waterway, for 1963 and 1992, based on number of individuals collected per hour of electrofishing. In 1963, 10 species accounted for 95% of all fish collected per hour, and catches were dominated by gizzard shad, carp, and emerald shiner. In 1992, 13 species accounted for 95.4% of all fish collected per hour, with bluegill being the most abundant, while gizzard shad, carp and emerald shiner were reduced in numbers in comparison to 1963. Overall, percentages for each species in 1992 were more evenly distributed than 1963, indicating no single species overwhelmingly dominated catches. Species are arranged in descending order of relative abundance in a clockwise direction and are labeled separately until approximately 95% of the pie is filled.

Middle Illinois Waterway

(Percentages based on number of fish collected per hour.)

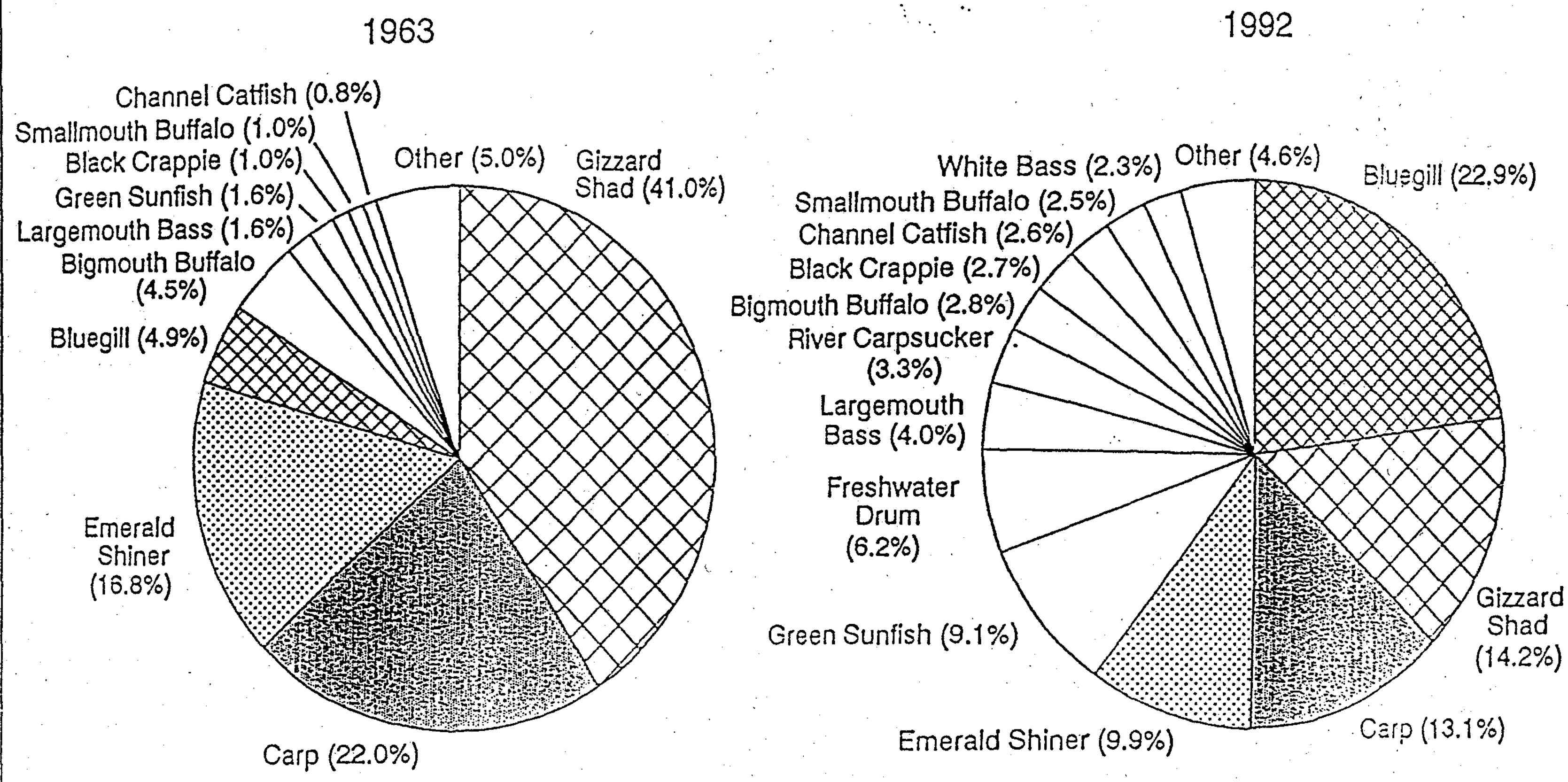

Figure 5. Percentages of catches by species for the lower Illinois Waterway, for 1963 and 1992, based on number of individuals collected per hour of electrofishing. In 1963, 11 species accounted for 95.5% of all fish collected per hour with two thirds of the catch being dominated by gizzard shad and the non-native carp (the most abundant fish). In 1992, 11 species accounted for 95.9% of all fish collected per hour; however, bluegill was the most abundant species. As in the middle waterway, percentages for each species in 1992 were more evenly distributed than 1963, indicating no single species overwhelmingly dominated catches. Species are arranged in descending order of relative abundance in a clockwise direction and are labeled separately until approximately 95% of the pie is filled.

Lower Illinois Waterway

(Percentages based on number of fish collected per hour.)

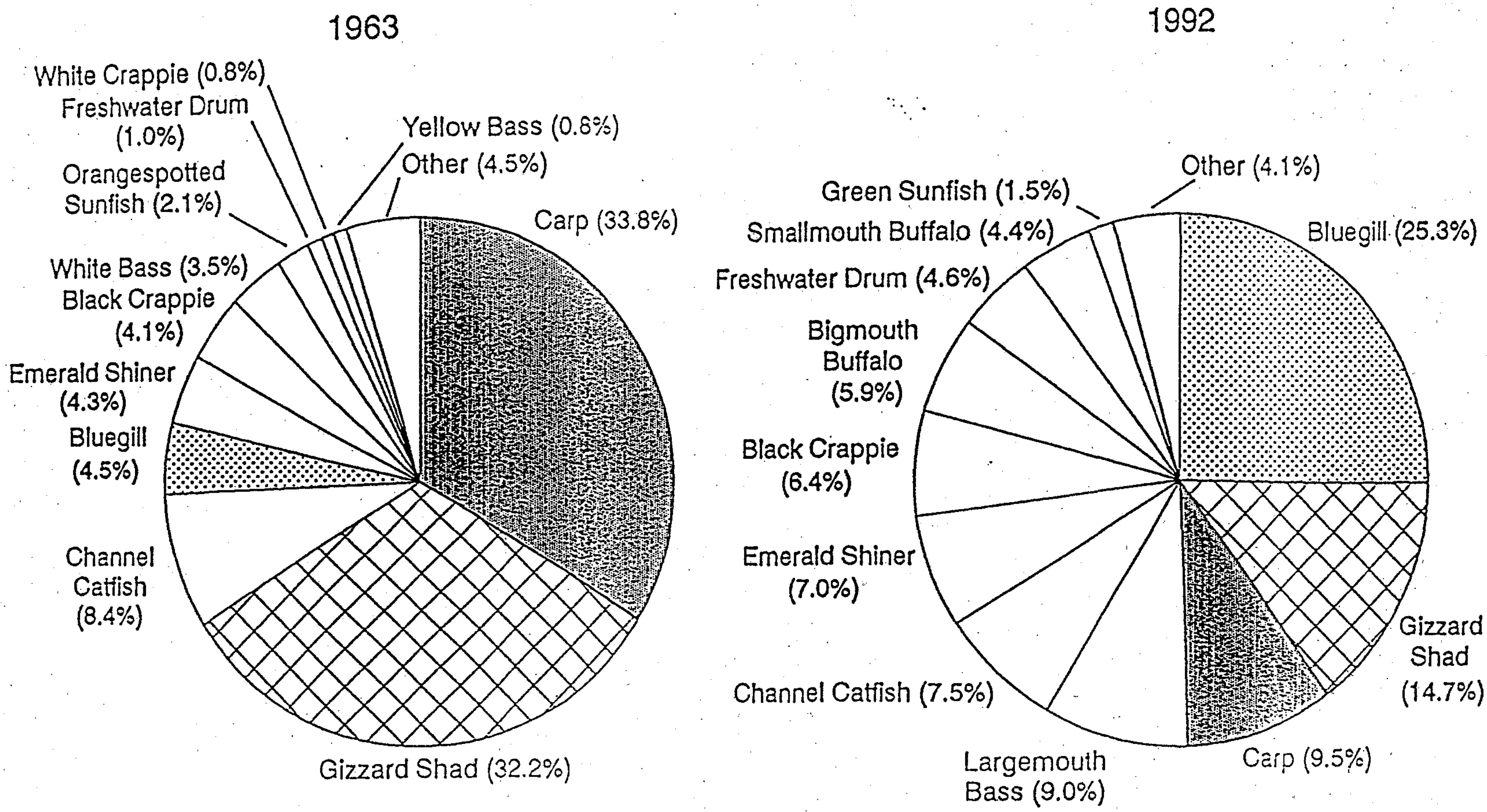

Figure 6. Incidence of externally-visible abnormalities (sores, eroded fins, lumps) on fishes which are likely to come into frequent contact with bottom sediments (bottom figure) and on fishes which mainly inhabit the water column (top figure) for 1963 and 1992. Numbers above each bar represent the total number of individuals caught for that river segment. Overall, for both years, the incidence of external abnormalities was higher on sediment contact fishes than on water column fishes, indicating irritating substances may be present in the sediments. The incidence of external abnormalities on sediment contact fishes in both 1963 and 1992 and on water column fishes in 1963 increased toward the Chicago area, implicating this area as the source of the factor or factors causing the abnormalities. Percentages were much lower in 1992 than in 1963, practically disappearing in water column fishes, indicating some reduction in the source.

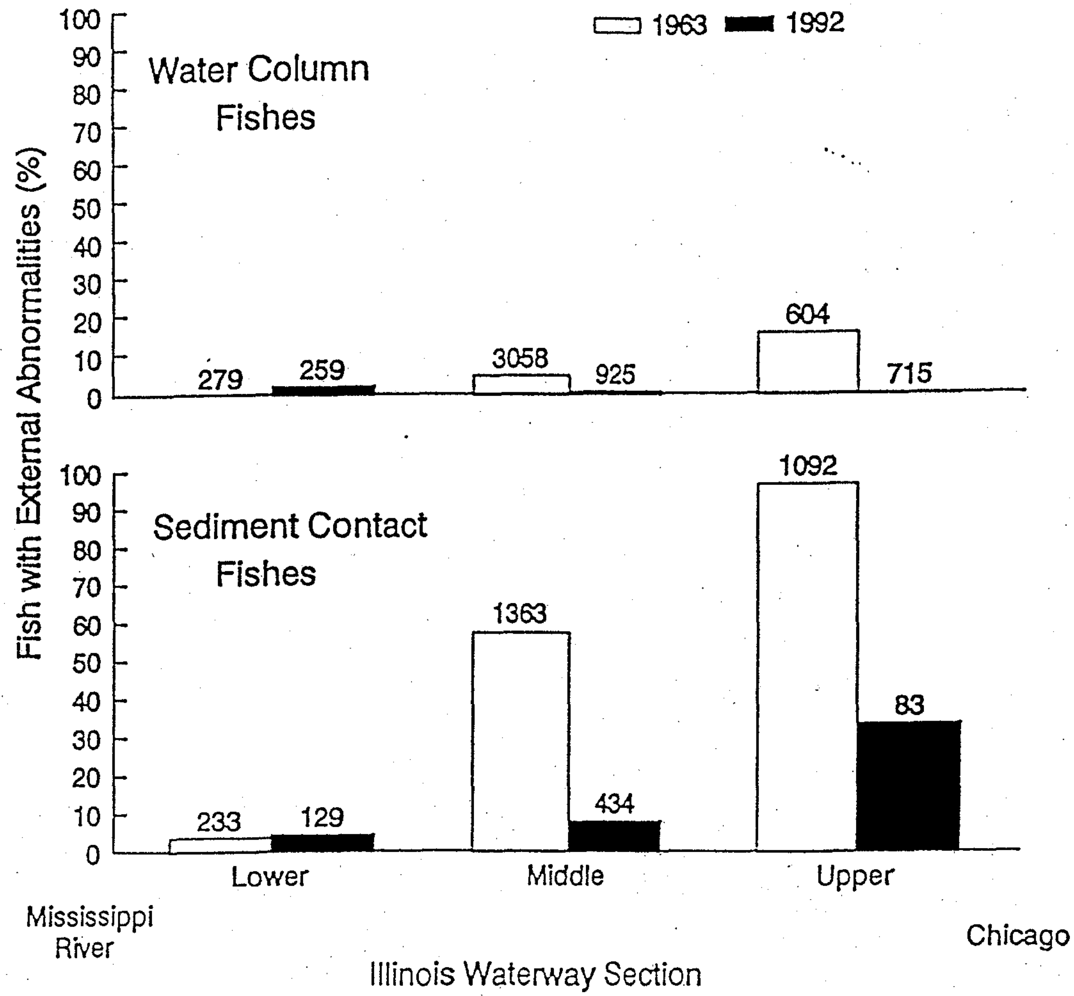
1963
1992
Water Column Fishes
Sediment Contact Fishes
Fish with External Abnormalities (%)
100
90
80
70
60
50
40
30
20
10
0
279
259
3058
925
604
715
233
129
1363
434
1092
83
Lower
Middle
Upper
Mississippi River
Chicago
Illinois Waterway Section

Figure 7. Response of fingernail clams to sediments collected in 1990 from the Upper Mississippi River, Illinois River, Des Plaines River, and Chicago waterways. Negative responses indicate toxicity and positive responses indicate stimulation. All the sediments from the Illinois River and Upper Mississippi River were nontoxic in these short term tests (1 hour of exposure), whereas all the sediments from the Chicago area were acutely toxic, except for one sample from the Sanitary and Ship Canal at mile 316. More sensitive tests with fingernail clams have demonstrated toxicity even in sediments from the middle section of the Illinois Waterway (Sparks, Sandusky and Paparo 1981). The toxicity is largely attributable to un-ionized ammonia, with some contribution from petroleum hydrocarbons (Sparks, Ross, and Dillon 1992). The fingernail clam was an important food organism for bottom-feeding fish and diving ducks in the middle and lower Illinois Waterway until it died out in the 1950s (Sparks 1984). As a result, the condition of bottom-feeding fish declined and diving ducks virtually ceased using the middle and lower waterway (Table 4 and Sparks 1984). The toxicity test measures how rapidly the clams remove food particles from water, following 1 hour of exposure to water extracted from the sediment samples. Reduction of feeding ultimately causes starvation and death of the clam. The horizontal dashed lines indicate significant response thresholds for inhibition or stimulation of feeding: 2 x the standard deviation + the mean difference in feeding rates determined in 18 control trials with no exposure to toxicants (Sparks, Ross, and Dillon 1992).

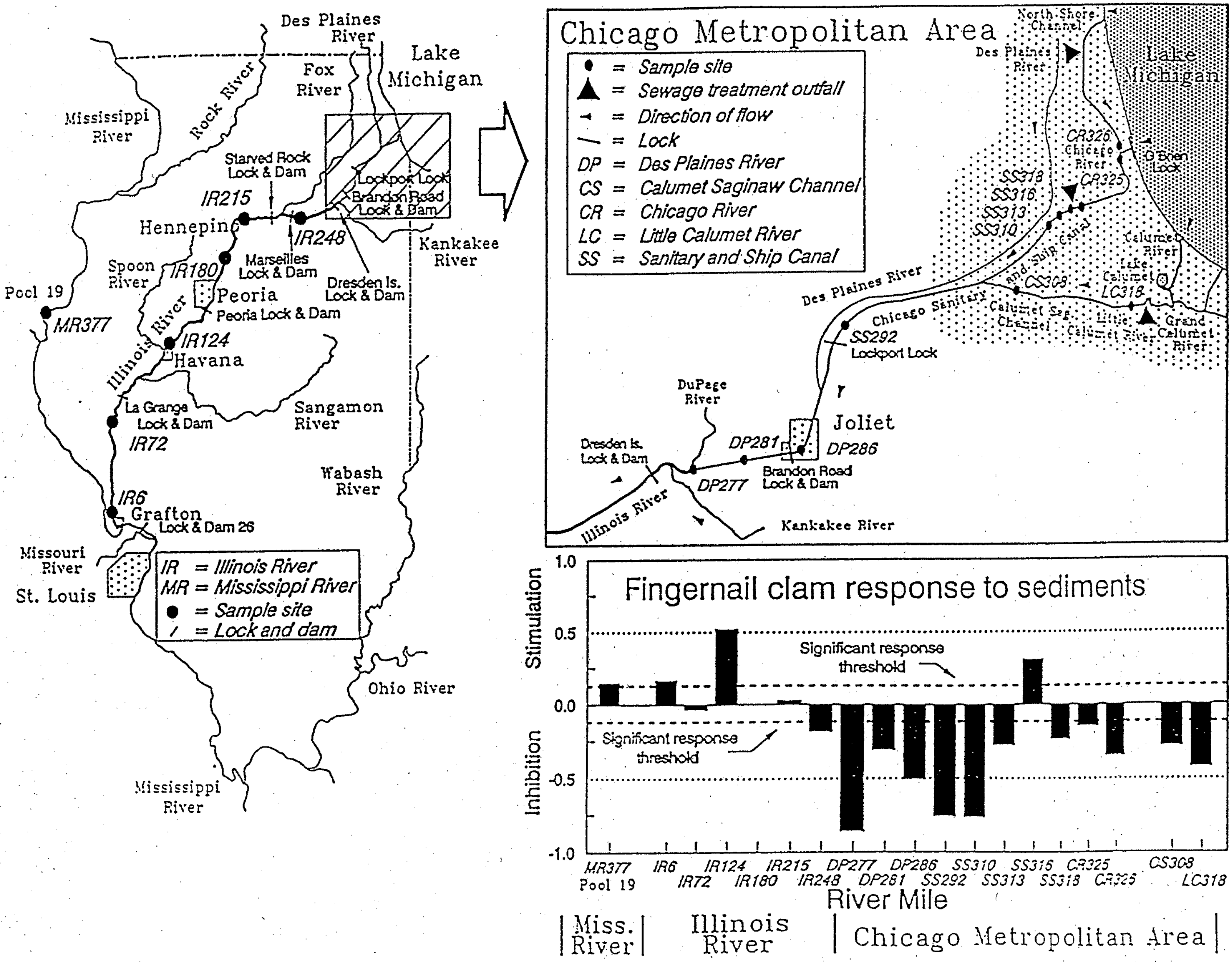
Des Plaines River
Fox River
Lake Michigan
Rock River
Mississippi River
Starved Rock Lock & Dam
Lockport Lock
Brandon Road Lock & Dam
IR215
IR248
Hennepin
Kankakee River
Spoon River
IR180
Marseilles Lock & Dam
Dresden Is. Lock & Dam
Pool 19
MR377
Peoria
Peoria Lock & Dam
Illinois River
IR124
Havana
La Grange Lock & Dam
IR72
Sangamon River
Wabash River
IR6
Grafton
Lock & Dam 26
Missouri River
St. Louis
IR = Illinois River
MR = Mississippi River
● = Sample site
/ = Lock and dam
Ohio River
Mississippi River
Chicago Metropolitan Area
● = Sample site
▲ = Sewage treatment outfall
= Direction of flow
= Lock
DP = Des Plaines River
CS = Calumet Saginaw Channel
CR = Chicago River
LC = Little Calumet River
SS = Sanitary and Ship Canal
North Shore Channel
Des Plaines River
Lake Michigan
CR326
Chicago River
CR325
O'Brien Lock
SS318
SS316
SS313
SS310
Calumet River
Lake Calumet
Sanitary and Ship Canal
CS308
LC318
Des Plaines River
Chicago Sanitary
Calumet Sag. Channel
Little Calumet River
Grand Calumet River
SS292
Lockport Lock
DuPage River
Joliet
Dresden Is. Lock & Dam
DP281
DP286
DP277
Brandon Road Lock & Dam
Illinois River
Kankakee River
Fingernail clam response to sediments
Stimulation
Inhibition
1.0
0.5
0.0
-0.5
-1.0
Significant response threshold
Significant response threshold
MR377 Pool 19
IR6
IR72
IR124
IR180
IR215
IR248
DP277
DP281
DP286
SS292
SS310
SS313
SS316
SS318
CR325
CR326
CS308
LC318
River Mile
Miss. River
Illinois River
Chicago Metropolitan Area

Table 1. Presence (dark or stippled)/absence (blank) in the upper Illinois Waterway of commonly occurring fish species (species accounting for 95% of all individuals collected in the Illinois Waterway, 1975-1992). Black bars indicate species that occurred in over 90% of years. Stippled bars indicate species that occurred in less than 90% of years. Dashed lines indicate years when electrofishing was not conducted. Five species were consistently collected in 90% or more of all years, two of which, goldfish and carp, are pollution-tolerant, non-native species. Carp x goldfish hybrids were also collected in most years, a fish usually associated with polluted conditions. Centrarchid species, usually identified as pollution-sensitive fishes (e.g., largemouth and smallmouth bass, bluegill, black crappie) have been collected more consistently since 1982 than in the earlier years of the survey, an indication of improved water quality.

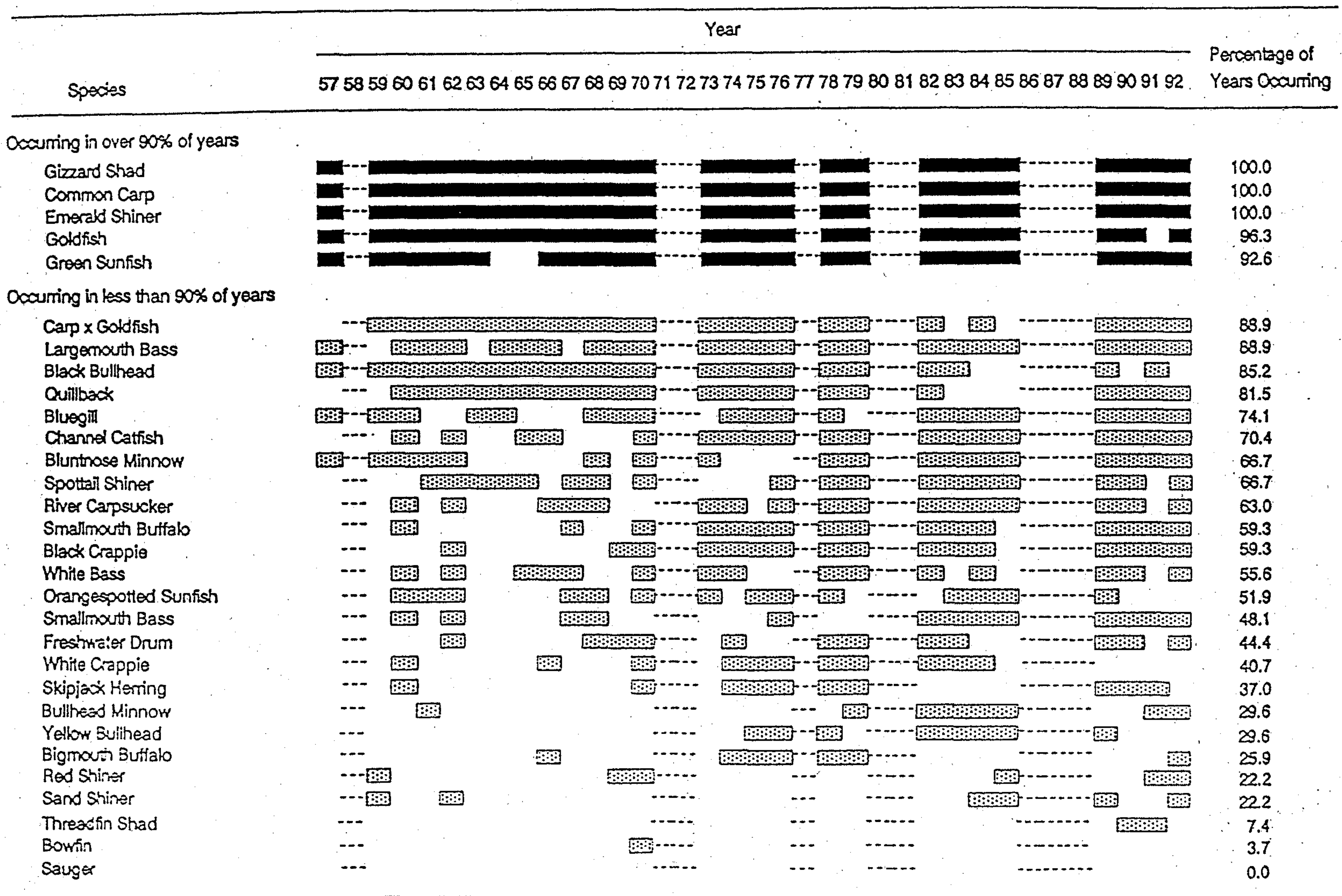
Year
Species
57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92
Percentage of Years Occurring
Occurring in over 90% of years
Gizzard Shad 100.0
Common Carp 100.0
Emerald Shiner 100.0
Goldfish 96.3
Green Sunfish 92.6
Occurring in less than 90% of years
Carp x Goldfish 88.9
Largemouth Bass 88.9
Black Bullhead 85.2
Quillback 81.5
Bluegill 74.1
Channel Catfish 70.4
Bluntnose Minnow 66.7
Spottail Shiner 66.7
River Carpsucker 63.0
Smallmouth Buffalo 59.3
Black Crappie 59.3
White Bass 55.6
Orangespotted Sunfish 51.9
Smallmouth Bass 48.1
Freshwater Drum 44.4
White Crappie 40.7
Skipjack Herring 37.0
Bullhead Minnow 29.6
Yellow Bullhead 29.6
Bigmouth Buffalo 25.9
Red Shiner 22.2
Sand Shiner 22.2
Threadfin Shad 7.4
Bowfin 3.7
Sauger 0.0

Table 2. Presence (dark or stippled)/absence (blank) in the middle Illinois Waterway of commonly occurring fish species (species accounting for 95% of all individuals collected in the Illinois Waterway, 1975-1992). Black bars indicate species that occurred in over 90% of years. Stippled bars indicate species that occurred in less than 90% of years. Dashed lines indicate years when electrofishing was not conducted. Twelve species were consistently collected in 90% or more of all years, which includes a larger number of pollution-sensitive centrarchid species (e.g., black and white crappie, largemouth bass, bluegill) than on the upper waterway (Table 1). The consistent occurrence of bigmouth buffalo, a native fish which requires backwaters for spawning, compared with the upper waterway (Table 1), is related to the much greater amount of backwater habitat along the middle river (Fig. 1).

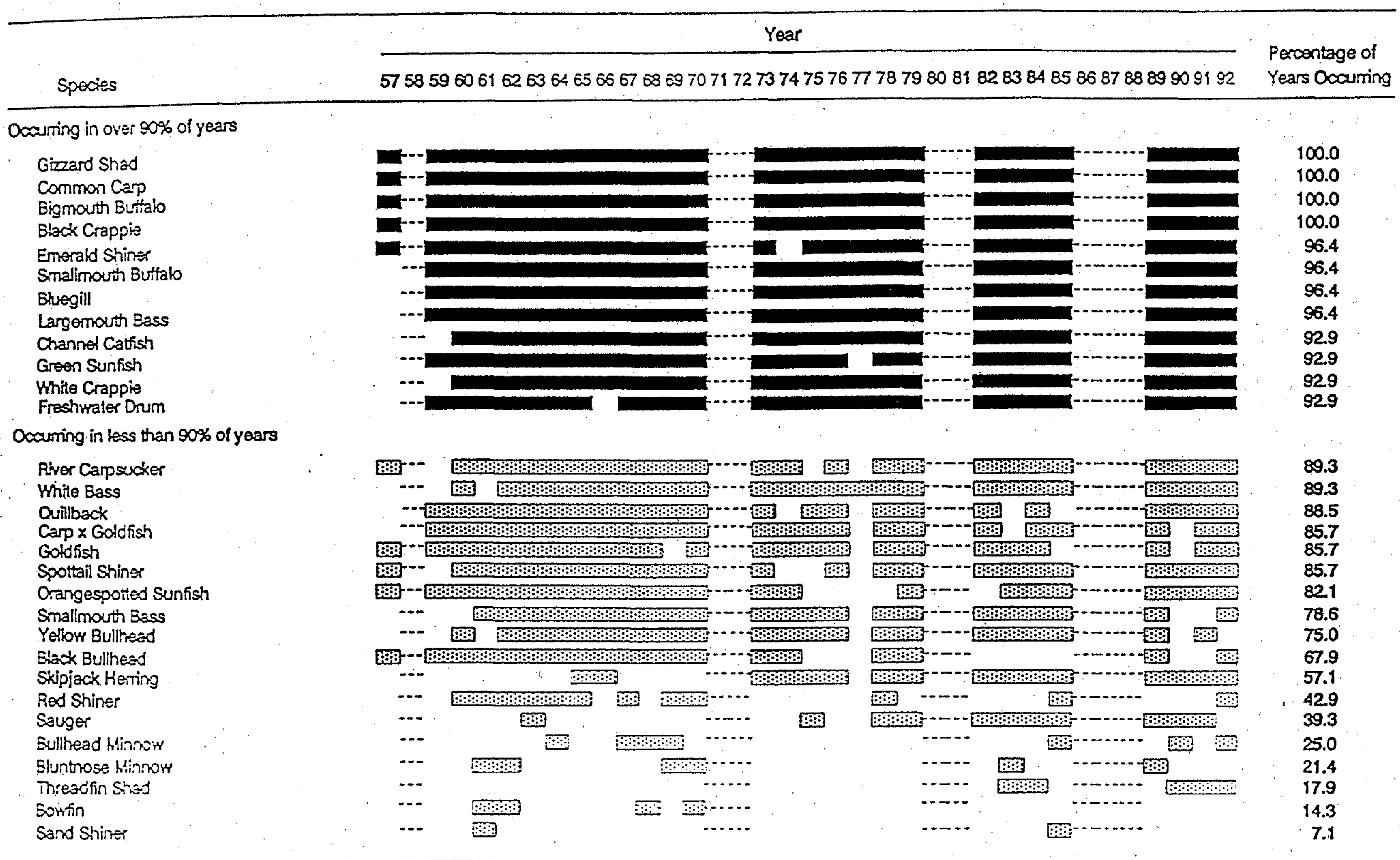
Year
Species
57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92
Percentage of Years Occurring
Occurring in over 90% of years
Gizzard Shad 100.0
Common Carp 100.0
Bigmouth Buffalo 100.0
Black Crappie 100.0
Emerald Shiner 96.4
Smallmouth Buffalo 96.4
Bluegill 96.4
Largemouth Bass 96.4
Channel Catfish 92.9
Green Sunfish 92.9
White Crappie 92.9
Freshwater Drum 92.9
Occurring in less than 90% of years
River Carpsucker 89.3
White Bass 89.3
Quillback 88.5
Carp x Goldfish 85.7
Goldfish 85.7
Spottail Shiner 85.7
Orangespotted Sunfish 82.1
Smallmouth Bass 78.6
Yellow Bullhead 75.0
Black Bullhead 67.9
Skipjack Herring 57.1
Red Shiner 42.9
Sauger 39.3
Bullhead Minnow 25.0
Bluntnose Minnow 21.4
Threadfin Shad 17.9
Bowfin 14.3
Sand Shiner 7.1

Table 3. Presence (dark or stippled)/absence (blank) in the lower Illinois Waterway of commonly occurring fish species (species accounting for 95% of all individuals collected in the Illinois Waterway, 1975-1992). Black bars indicate species that occurred in over 90% of years. Stippled bars indicate species that occurred in less than 90% of years. Dashed lines indicate years when electrofishing was not conducted. Ten species were consistently collected in 90% or more of all years, which includes pollution-sensitive centrarchid species (e.g., largemouth bass, bluegill, black and white crappie) as well as white bass. In sharp contrast to the other sections of the river, goldfish and carp x goldfish hybrids, non-native pollution-tolerant fishes, were collected in few years, an indication that the lower waterway suffers less from urban and industrial wastes. Small minnow species (e.g., red shiner, sand shiner, spottail shiner, bluntnose and bullhead minnows) were less consistently collected from the lower waterway than the upstream sections, which could reflect differences in habitat conditions (e.g., fewer aquatic plants for use as cover than the upper waterway, fewer backwaters than the middle section, the leveeing and draining of the floodplain) or other factors as yet undetermined.

Species	Percentage of Years Occurring
Occuring in over 90% of years	
Gizzard Shad	100.0
Common Carp	100.0
Channel Catfish	100.0
White Bass	100.0
Black Crappie	100.0
Bluegill	95.5
Largemouth Bass	95.5
Freshwater Drum	95.5
Emerald Shiner	90.9
White Crappie	90.9
Occuring in less than 90% of years	
Bigmouth Buffalo	86.4
Green Sunfish	72.7
River Carpsucker	68.2
Smallmouth Buffalo	59.1
Quillback	40.9
Skipjack Herring	36.4
Sauger	36.4
Orangespotted Sunfish	31.8
Threadfin Shad	18.2
Smallmouth Bass	18.2
Bowfin	13.6
Yellow Bullhead	13.6
Carp x Goldfish	9.1
Red Shiner	9.1
Goldfish	4.5
Spottail Shiner	4.5
Black Bullhead	4.5
Bluntnose Minnow	0.0
Bullhead Minnow	0.0
Sand Shiner	0.0

Table 4. Mean relative weight (Wr) for bluegill and carp for 1963, 1975, and 1991. Wr is determined by dividing an individual fish's weight by a length-specific standard weight (Ws), where Ws represents the top quartile of fish from a specific region (Murphy et al. 1991). A Wr equal to or greater than 1.0 indicates a healthy fish and, therefore, favorable ecological conditions, while a Wr less than 1.0 may indicate a food supply problem or some other factor (pollution stress) which is unhealthful to fish. Bluegill, which mainly inhabit the water column rather than foraging on the bottom, had a mean Wr close to 1.0 for 1963, 1975, and 1991, indicating that food supply may not be a problem for these species. In contrast, mean Wr's for carp, a bottom-feeding omnivore, were consistently less than 1.0 for all three years, indicating their environment may be less than conducive to healthy growth or that the food supply is limited in quantity or quality. Sparks (1984) and Starrett (1971) related the poor condition of bottom-feeding fishes to the lack of invertebrates (fingernail clams, aquatic worms and insects) on the bottom of the river. The lack of invertebrates is in turn linked to the occurrence of toxic levels of ammonia in the sediments (see Fig. 7).

	Bluegill		Carp	
Year	N	Mean Wr	N	Mean Wr
1963	50	0.914	995	0.877
1975	123	0.984	449	0.781
1991	347	1.06	114	0.795