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BROWN BULLHEAD

(*Ameiurus nebulosus*)

The brown bullhead was first described from Philadelphia in the early nineteenth century, when it was common and savored. Recent fish surveys in Center City have not detected it.

Figure 21.1 Brown bullhead (*Ameiurus nebulosus*) caught in Driscoll Pond, Haddonfield, New Jersey, by Leo Sheng. (Photo by Leo Sheng)

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In 1819, Charles Alexandre Lesueur, a member of the Academy of Natural Sciences of Philadelphia, described and named a species of catfish new to science. He reported that the species, now designated as *Ameiurus nebulosus,* was very common in Philadelphia ("tres nombreuse à Philadelphie") and that people fished for it and had high regard for its white flesh.[1] According to Thaddeus Norris, an expert on fish culture at the time, this species inhabited ponds, ditches, and creeks, including tidal water.[2] He contrasted it with the bigger catfish (*Ameiurus catus*) also native to Philadelphia's waters:

> If these smaller species were not so common they would be more generally esteemed. These are far better fish for the pan; their flesh is firm and sweet, and resembles that of the trout or the breast of a young chicken, more than the flesh of any other fish. "Catfish and coffee" at the Falls of Schuylkill was formerly and to some extent is still an "institution."[3]

Historic abundance in the Schuylkill River

In 1914 Henry Fowler, ichthyologist at the Academy, noted that fish in the Schuylkill River were more common than one might have expected, given the severity of the river's pollution:

> For many years the tidal reaches of the Schuylkill River to the Fairmount Dam in Philadelphia have been greatly polluted, suggesting the impression that they support little or no fish life. I have recently received a number of fishes from this region, through Mr. W. E. Meehan, the Director of the Philadelphia Aquarium, besides notes on others not sent.[4]

He listed thirteen species that he ranked as common, including *Ameiurus nebulosus.*[5]

The "Schuylkill cat," as *A. nebulosus* was called in the early twentieth century,[6] or the "brown bullhead," as it is known today, is distinctive for its tolerance of pollution. A guide to game fish published in 1905 offers a description alleged to be by Henry David Thoreau:

> They stay near the bottom, moving slowly about with their barbels widely spread, watching for anything eatable. They will take any kind of bait, from an angleworm to a piece of tomato can, without hesitation or coquetry, and they seldom fail to swallow the hook.[7]

Diet of nonbiting midges (chironomids)

An evaluation of the contents of stomachs of brown bullheads from a lake in New York found that they selectively ate chironomid larvae—wormlike aquatic stages of nonbiting midges, which are flies. These larvae live in sediment and belong to the largest and most ecologically diverse family of aquatic insects.[8] In Lake Erie, where brown bullheads are common, numbers of chironomids increased fourfold from 1930 to 1961, a period when pollution increased;[9] chironomid abundance subsequently decreased when pollution abated.[10] Compared to brown bullheads in Lake Erie's less polluted tributaries, those in the most polluted waters grew larger and produced more eggs per female.[11]

The abundance of chironomids in polluted water helps explain their possible contribution to the brown bullhead's tolerance of pollution. In the course of an evaluation of an outbreak of chironomid midges, the population density of chironomid larvae in mud samples taken from a lake bottom polluted from runoff from the Twin Cities

was 7,000 individuals per square yard.[12] Chironomid midges around bodies of polluted water in urban areas have been treated as pests.[13] In the Delaware River basin, which includes the Schuylkill River, 18 percent of the genera of all aquatic invertebrates belong to the family Chironomidae.[14]

Figure 21.2

Figure 21.3

Figure 21.4

Figure 21.5

Figure 21.6

Figure 21.7

Figures 21.2–21.7 Chironomids, or nonbiting midges. Their aquatic larvae are favorite prey of brown bullheads. These midges were attracted to black light in our backyard, several blocks from the Schuylkill River. They belong to the most species-rich family of aquatic animals.

Diet of worms (oligochaetes)

Other aquatic fauna may have contributed to the bullhead's pollution tolerance that Henry Fowler observed in the tidal Schuylkill. Like chironomids, oligochaetes have proliferated in rivers with increasing pollution.[15] Oligochaetes are segmented worms in the same taxonomic class as earthworms.[16] When oligochaetes in a polluted river outnumbered chironomid larvae, brown bullheads ate more oligochaetes than chironomids, even though the fish favored chironomids.[17] In a survey of macroinvertebrates on the bottom of the tidal Schuylkill River in 1975 and 1976, oligochaetes were the most abundant animals, numbering over 6,000 per square meter. By weight and by numbers, they constituted over 98 percent of the macroinvertebrate fauna on the bottom of the river.[18]

If oligochaetes and chironomids were the reason that brown bullheads tolerated pollution in the Schuylkill River, why did Joseph Leidy not find them in the sediment dredged from the bottom of the Schuylkill River in 1876?[19] Freshwater invertebrates, especially oligochaetes, were one of his specialties, particularly the genus *Limnodrilus,*[20] which constituted 99 percent of the oligochaetes identified in the Schuylkill River survey.[21] Perhaps the bituminous sediment that Leidy found was distributed unevenly in the riverbed, which supported aquatic life in sections with less contamination.

Diet of sewage

Alternatively, pollution may have supplied brown bullheads with food other than oligochaetes and chironomids. The brown bullhead's diet in polluted sections of the Monongahela River in West Virginia suggests what this mysterious other food might have been. In a study of the stomach contents of brown bullheads in the Monongahela, the food brown bullheads ate in greatest volume was not prey but sewage, and the second greatest was detritus. Although they did consume oligochaetes and chironomids, by volume the fraction of the brown bullhead's diet consisting of sewage and detritus was 70 percent.[22] In Philadelphia in 1876, brown bullheads may have been able to compensate for scarcity of prey by eating sewage and detritus.

Tolerance of pollution

Compared to other fish, brown bullheads are better able to tolerate extreme conditions associated with pollution. These include water that is acidic (pH 3.3),[23] hypoxic (oxygen 0.5–1 mg/liter),[24] and warm (temperature 40°C [105°F]).[25] In an impoundment in the upper Schuylkill, they have lived with sediments contaminated with lead, cadmium, chromium, copper, and zinc, and they showed no gross pathology.[26] Brown bullheads living in a tidal creek contaminated with heavy metals in North Carolina showed no histologic, biochemical, or hematologic abnormalities.[27]

Benefits of pollution for brown bullheads

Like the freshwater sponge *Spongilla fragilis,* the brown bullhead may tolerate pollution better than its enemies. Brown bullheads defend their eggs and young from predators such as minnows and sunfishes, which they chase away.[28] The U.S. Environmental Protection Agency has classified as tolerant of pollution only a quarter of species of minnows (cyprinids) and less than 10 percent of species of sunfish (centrarchids).[29] The native redbreast sunfish (*Lepomis auritus*) had become uncommon in the polluted tidal Schuylkill River according to Fowler's report in 1914.[30]

In 1999 Anthony C. Steyermark at Drexel University and his colleagues found that tapeworms (cestodes; *Proteocephalus* sp.) parasitized all brown bullheads from a pond in a residential area in New Jersey, whereas in the urban industrialized Schuylkill River, cestodes parasitized no brown bullheads. The cestodes attacked the fishes' hearts, livers, kidneys, and gonads, which carried high parasite burdens; one fish harbored 314 cestodes. Fish from the pond were stunted compared to those from the Schuylkill River. Steyermark et al. suggested that contamination in the Schuylkill River protected brown bullheads from these cestodes, whose larvae require crustaceans as intermediate hosts.[31]

Pollution may protect brown bullheads from consumption by fisherman. The Pennsylvania Department of Environmental Protection issues annual guidelines on the safety of eating fish caught locally. It tests fish for two contaminants: mercury and PCBs (polychlorinated biphenyls). Because of PCBs, it recommends limiting consumption of fish caught in the tidal Schuylkill River to one meal a month for all fish it tested except carp and eels, which it recommends never be eaten.[32] Although the guidelines are intended to protect people, they may also protect fish.

Figure 21.8 Fishermen near the 30th Street train station. The boat in the background belongs to the Philadelphia Water Department, which monitors the quality of both the water and fish.

The presence of PCBs in fish caught in the Schuylkill River does not necessarily deter fishermen from eating them. One study found that, compared to non-Hispanic white fishermen, non-Hispanic black fishermen were more likely to fish in watersheds with high PCB contamination and more likely to consume catfish. It suggested that consumption of contaminated catfish caught by fishermen is the reason levels of PCBs are higher in non-Hispanic blacks than in non-Hispanic whites.[33]

Contamination of brown bullheads may suppress reproduction in fish-eating birds. Contamination of fish with chlorinated hydrocarbons was first shown to suppress reproduction in birds in the case of bald eagles and the pesticide DDT,[34] but other chlorinated hydrocarbons (such as PCBs) have caused similar effects and have involved other fish-eating birds, including herons,[35] cormorants,[36] and ospreys,[37] all of which I have observed preying on fish in the Schuylkill River in Philadelphia. In 1984, chlordane, DDT, dieldrin, and PCBs in the Schuylkill River in Philadelphia were found at four trophic levels, exemplified by green algae, snails, minnows, and largemouth bass.[38] Oligochaetes and chironomids in riverbeds ingest PCBs from the sediment and pass them on to fish, which in turn pass them on to their predators. This transmission up the food chain concentrates PCBs, which are lipid soluble and accumulate in animal fat.[39]

Figure 21.9 Great blue heron (*Ardea herodias*) fishing at Boathouse Row. Like brown bullheads, it prefers shallow, quiet water.

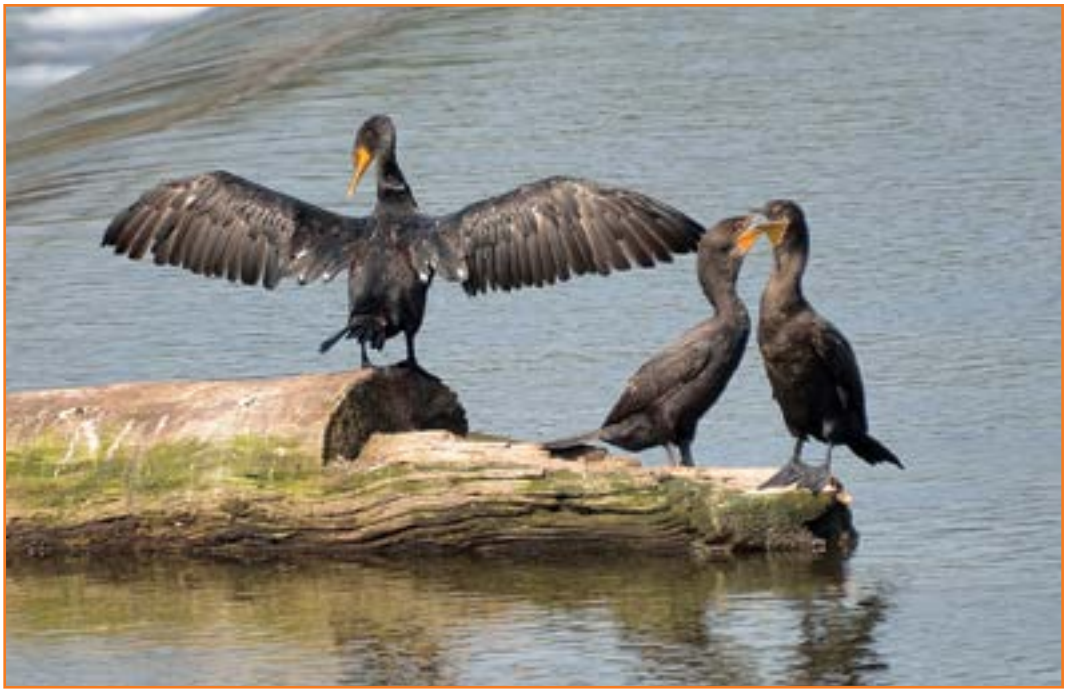

Figure 21.10 Double-crested cormorants (*Phalacrocorax auritus*) on a log grounded at the Fairmount Dam. This diving bird fishes in the lower Schuylkill in Center City. The posture with spread wings is typical.

Figure 21.11 Great egret (*Ardea alba*) at Columbia railroad bridge over the Schuylkill River, Philadelphia.

Costs of pollution to brown bullheads

For brown bullheads, the benefits of tolerance of pollution may have costs, such as exposure to carcinogens. In 1941 Balduin Lucké and Hans G. Schlumberger at the University of Pennsylvania School of Medicine and Wistar Institute described tumors on the lips of 166 brown bullheads from the Schuylkill and Delaware Rivers around Philadelphia:

> This neoplasm usually occurs as solitary or multiple, large, red, fleshy masses upon the lips or dental plates, and by reason of its size, may prevent closure of the mouth...The larger growths frequently invade adjacent normal tissues and force their way into vessels where they are found as emboli. The clinical course of the tumor is one of relatively slow but progressive growth.[40]

The tumors as they described them bear features typical of malignancy, and later authors classified them as such (squamous cell carcinoma).[41] In 2004 liver cancers were found in 26 percent of brown bullheads in Darby Creek in Philadelphia's John Heinz National Wildlife Refuge at Tinicum, a habitat so highly contaminated that the U.S. Environmental Protection Agency designated it a hazardous waste Superfund site.[42] In a study sponsored by the Delaware River Basin Commission, brown bullheads collected at various sites in the Delaware River were found to have lip tumors and liver lesions.[43]

The evidence of a causal relationship between chemical pollutants and tumors was initially compelling.[44] Prevalence of tumors in brown bullheads was found to be high in contaminated industrial sites compared to uncontaminated sites in widely scattered locations in the United States, especially in the East and Midwest.[45] In the laboratory, brown bullheads dosed with extracts of sediment containing industrial pollutants (polycyclic aromatic hydrocarbons, or PAHs) developed liver and skin tumors indistinguishable from tumors they developed in the wild.[46] Prevalence of liver tumors in brown bullheads in the Black River in Michigan dropped after a coking plant shut down and the river was dredged, reducing PAH contamination.[47]

Despite strong evidence incriminating pollution, brown bullheads in uncontaminated reservoirs and ponds in New York State were found to have a prevalence of tumors reaching 100 percent for skin and 30 percent for liver or bile ducts.[48] In the South River on the Chesapeake Bay, prevalence of tumors in brown bullheads was high despite the absence of high concentrations of known carcinogens.[49] Descendants of brown bullheads from the Delaware River estuary that fisheries personnel introduced into ponds developed tumors, suggesting transmission of an infectious or genetic carcinogen from river to pond.[50] The cause of tumors in brown bullheads remains enigmatic.

Disappearance of brown bullheads

Populations of brown bullheads have been in decline in the Schuylkill River in Philadelphia. Fish surveys here from 2002 to 2006 identified no brown bullheads among 44,000 fish identified. These surveys identified locally introduced game fish, including 3,499 channel catfish (*Ictalurus punctatus*), a competitor of brown bullheads, and 469 flathead catfish (*Pylodictis olivaris*), a predator of brown bullheads.[51] The surveys sampled fish populations by electrofishing in the Schuylkill River below

the Fairmount Dam, and by video observation in the fish ladder at the Fairmount Dam. In contrast, brown bullheads were abundant in samples obtained by trawling and electrofishing in the tidal Schuylkill River from 1971 to 1976.[52] In 1979 they were observed in large numbers in the "turn-pool" at the base of the fish ladder.[53] A fisherman told me he recently caught brown bullheads with rod and reel in Center City at night in the summer.[54]

Figure 21.12 Channel catfish (*Ictalurus punctatus*), the most common catfish reeled in from the Schuylkill River in Center City. Its introduction as a game fish likely contributed to declines in brown bullheads, which are native to the Schuylkill River.

The scarcity of brown bullheads has been attributed in part to decreasing pollution.[55] The manufacture of PCBs, for example, was banned in 1979 by the U.S. Environmental Protection Agency under the federal Toxic Substances Control Act.[56] As pollution decreased, populations of brown bullheads lost a comparative advantage over predators and competitors less tolerant of pollution. A less toxic Schuylkill may have destroyed a safe haven for brown bullheads in Center City. Brown bullheads, however, thrived in the Schuylkill before the advent of industrial pollution. Introduction of game fish such as the flathead catfish (*Pylodictis olivaris*)[57] and channel catfish (*Ictalurus punctatus*)[58] may have taken a toll that compounded that caused by reduced pollution. Joseph Perillo, aquatic biologist at the Philadelphia Water Department, has confirmed the recent introduction and establishment of another fish-eating predator, the northern snakehead (*Channa argus*),[59] whose prey includes brown bullheads.[60]

In addition to introduced game fish and cleaner water, Schuylkill bulkheads made out of concrete, wood, and steel may have adversely affected populations of brown bullheads. Bulkheading deprives brown bullheads of shallow water—which they prefer—along riverbanks, and no streams or ponds connect to the banks of the

Schuylkill in Center City. Aggravating the adverse effects of bulkheading, brownish flocculent material (visible in shallow water at low tide) obscures the riverbed and potential prey such as oligochaetes, chironomids, and crustaceans. Brown bullheads feed on green plants when they are available, but aquatic vegetation other than algae was absent in a study of the riverbed of the tidal Schuylkill in the late twentieth century.[61]

Power plants' cooling water intake pipe

The Exelon Generation Company operates a cooling system that pumps water from the Schuylkill River to a cluster of three power plants located on the east bank of the Schuylkill at Christian Street, a few blocks south of Center City.[62] The three plants have a combined generating capacity of 421 megawatts,[63] which is about 20 percent of the capacity of the Limerick Nuclear Power Plant on the Schuylkill River upstream in Montgomery County.[64] The cooling systems of the three plants draw cooling water from the river through an intake pipe 34 meters in length and 3 meters in diameter. From 2001 to 2005, pumps drew water through the intake pipe at an average rate of 170,000 liters per minute. After water traverses the length of the pipe, it passes through a traveling screen that diverts fish and debris into a trash trench; from here the fish are transported for disposal offsite. Eggs, larvae, fish, and debris tiny enough to pass through the screen mesh (3/8 inch, or about 1 centimeter) are pumped with the cooling water around the power plants and eventually discharged back into the river.[65]

Figure 21.13 Cluster of three power plants on the Schuylkill River at Christian Street, a few blocks south of Center City. View is from the Schuylkill Expressway. A cooling water intake structure along the shoreline draws water from the river. Fish sucked through a pipe strike a screen that diverts them into a trash trench for disposal offsite.

In an Exelon-sponsored study in 2005 and 2006, samples of fish impinged against the screen at the end of the water intake pipe included a single brown bullhead,[66] compared to 109 brown bullheads in 1975 and 192 in 1976.[67] Perhaps mortality of brown bullheads sucked into the water intake pipe over many decades contributed to their disappearance. Brown bullheads, which spawn in water 2 meters deep or less,[68] may have selectively positioned themselves near the opening to the cooling water intake structure, which is located on the shoreline. Also potentially harmful to brown bullheads is the heat of the effluent that the power plants' cooling system discharges into the river.[69]

The magnitude of the risk that the cooling water intake pipe poses to brown bullheads may be considered in the context of the magnitude of water flowing through the pipe compared to the river. The U.S. Geological Survey reports the median discharge of water from the Schuylkill River in Philadelphia for the last 80 years for any day of the year. For example, for September 13, the median discharge rate was 1.3 million liters per minute; the minimum rate for that day was 39,000 liters per minute (in 1966).[70] The historic flow of water through the cooling water intake pipe averaged over four times more than the river's historic minimum discharge rate for that day. The capacity of the cooling water intake pipe to draw in more water than the river discharges is possible because the river is tidal here, connected to the Atlantic Ocean via Delaware Bay.

Options to protect fish from intake pipes

The Exelon Generation Company considered several alternatives for reducing fish mortality in its cooling water intake structure, but rejected all in favor of the status quo.[71] The U.S. Environmental Protection Agency is currently (as of 2012) considering new standards[72] that may require power plants like Exelon to modify these structures.

Cooling water could be recycled back to the power plants rather than dumped, minimizing the need to pump water out of the river; but such a system would require cooling towers, which in turn would require more space than is available at the existing power plants.[73] Such towers would loom over the neighborhood, and consumers of electric power presumably would bear the costs of construction.

Burdensome accommodations might appear unwarranted on behalf of a species as widespread and generally common as the brown bullhead, but they might be justified on behalf of the river's overall health. Consultants for Exelon estimated that in 2006 the number of fish eggs and larvae "entrained" (i.e., drawn into the intake pipe past the screen mesh to the electrical power plants and discharged back into the river) totaled 1.5 million, encompassing eleven species.[74] In a study of a power plant on the shore of Lake Erie, mortality of juvenile and adult fish pumped into the cooling intake pipe was virtually 100 percent, independent of "entrainment" or "impingement" (i.e., removal and disposal of fish that strike barrier screens).[75]

Charisma

The fate of species in cities is sometimes linked to prejudice either for or against them, as in the case of the common milkweed, gray squirrel, and American robin. Charismatic species may be beneficiaries of special treatment, as exemplified by the presentation of dead rats by the Franklin Institute to red-tailed hawks nesting on its facade.[76]

In the early nineteenth century, Thaddeus Norris observed that the brown bullhead's flavor was better than its reputation.[77] In "A Plea for the Bullhead," the nineteenth-century humorist George Wilbur Peck mused over the brown bullhead's lowly status:

> The same may be said of brook trout. While they will bite a hook, it requires more machinery to catch them than ordinary people can possess without mortgaging a house. A man has got to have a morocco book of expensive flies, a fifteen dollar bamboo jointed rod, a three dollar trout basket with a hole mortised in the top, a corduroy suit made in the latest style, top boots, of the Wellington pattern, with red tassels in the straps, and a flask of Otard brandy in a side pocket. Unless a man is got up in that style, a speckled trout will see him in Chicago, first, and then it won't bite. The brook trout is even more aristocratic than the whitefish, and should not be propagated at public expense.
>
> But there are fish that should be propagated, in the interest of the people. There is a species of fish that never looks at the clothes of the man who throws in the bait, a fish that takes whatever is thrown to it, and when once hold of the hook never tries to shake a friend, but submits to the inevitable, crosses its legs and says "Now I lay me," and comes out on the bank and seems to enjoy being taken. It is a fish that is the friend of the poor, and one that will sacrifice itself in "the interest of humanity." That is the fish that the State should adopt as its trademark, and cultivate friendly relations with, and stand by. We allude to the bullhead.
>
> To catch the bullhead it is not necessary to tempt his appetite with porterhouse steak, or to display an expensive lot of fishing tackle. A pin hook, a piece of liver, and a cistern pole, is all the capital required to catch a bullhead. He lays upon the bottom of a stream or pond, in the mud, thinking. There is no fish that does more thinking, or has a better head for grasping great questions, or chunks of liver, than the bullhead.[78]

In theory, public policy might support intervention to protect brown bullheads if the fish had more charisma, or if they attracted charismatic predators, such as bald eagles. Bald eagles nest in Philadelphia.[79] They occasionally appear in the Schuylkill River outside Bartram's Garden, just two kilometers downstream from the cooling water intake pipe. In a study of bald eagles nesting on the Potomac River, approximately 95 percent of the remains of their prey were catfish, primarily brown bullheads.[80]

The fate of the brown bullhead in the tidal Schuylkill River may depend less on its charisma than on the charisma of its enemies, the channel catfish and flathead catfish. The introduction of these two popular game fish is the most compelling explanation for the brown bullhead's local disappearance, a result that is likely irreversible in Center City. Bald eagles prey on all three species of catfish.[81]