

Fisheries of the Hudson River

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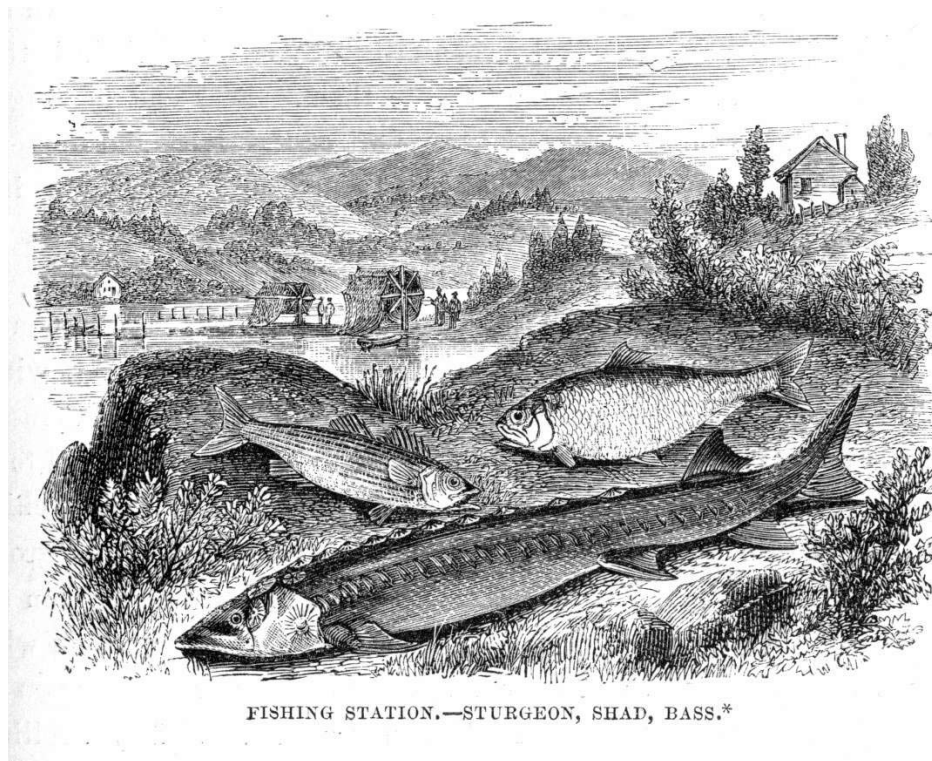


Figure from Lossing (1866)

Introduction

Of all the relationships humankind entertains with the Hudson River, perhaps none is so intimate as that of fishing. The harvest of fish and shellfish from the Hudson has endured for thousands of years, and connects us both with the River's productivity and with our cultural past.

Other chapters in this book describe the fish fauna and its use of various habitats within the system. Here, we concentrate on the fisheries themselves, focusing on key species within the commercial and sportfishing arenas. We also examine some of the factors that potentially have large effects on fisheries, namely, the impacts of power plants that withdraw water from the river, and the persistence of contaminants, especially PCBs.

Historical Importance of Hudson River Fisheries

Artesian and Commercial

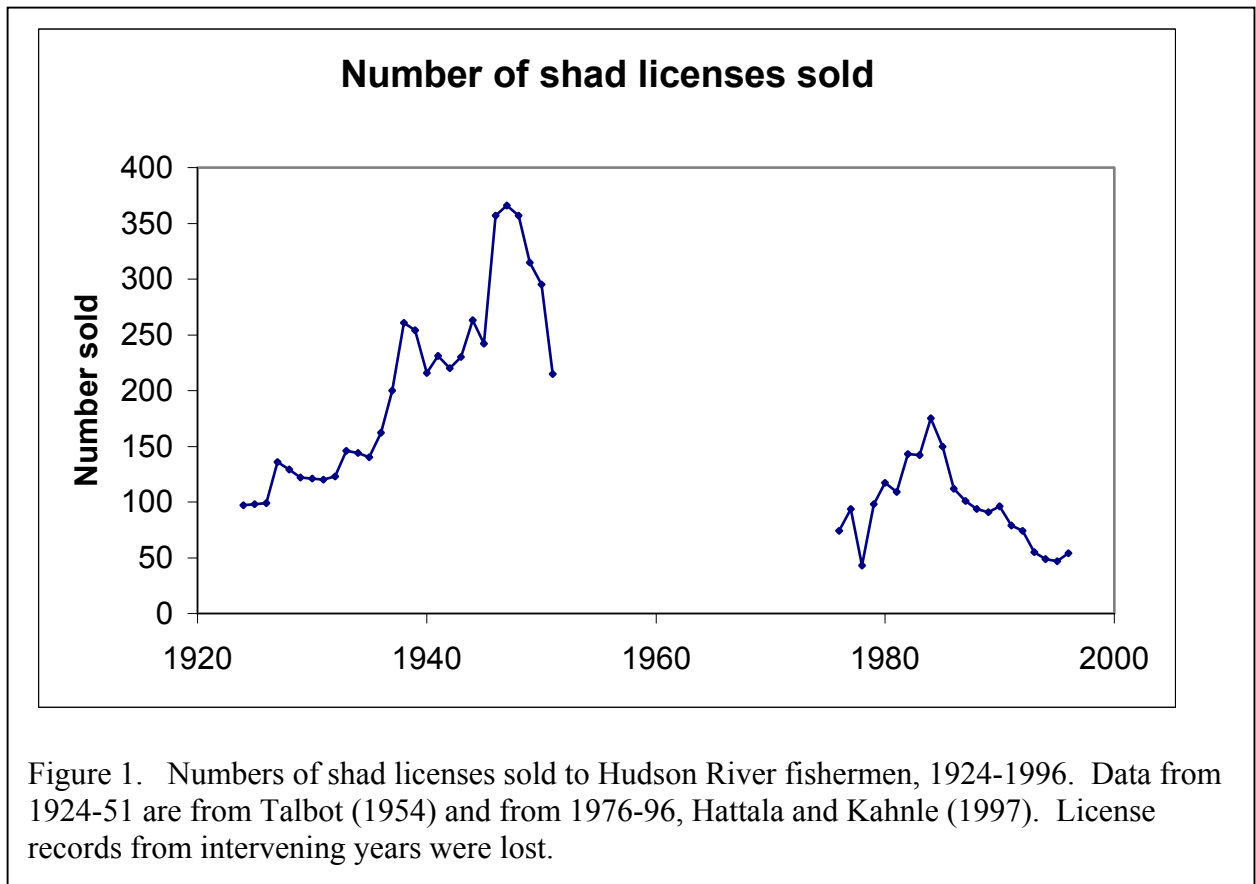
Before modern agriculture and globalization of products, the fisheries of the Hudson River were an important and diverse local source of protein. Native Americans harvested fish and shellfish long before the arrival of European settlers. Dating of the oyster middens at Croton Point Park show that humans fished there seven millennia ago (www.co.westchester.ny.us/parks/LocationPages/CrotonPoint.htm). Middens at Tivoli Bays in the upper tidal Hudson bear evidence of the consumption of fish and even bland-tasting freshwater mussels (Funk 1992). Adriean Van der Donck, one of the documenters of the first Dutch settlements, noted "this river is full of fishes" (Boyle 1979). Settlers could feast on finfish, including American shad, sturgeons, and striped bass, as well as on blue crab, scallops, and the plentiful oysters that extended throughout the Harbor, East and Harlem Rivers, and up the Hudson as far as Stony Point. Oysters from Gowanus Bay were the size of dinner plates and especially sought after (Waldman 1999). The Hudson River beds produced well over 450,000 barrels (50,000 m³) of oysters per annum in the early 19th century (Boyle 1979).

Commercial fishers in the eighteenth and nineteenth centuries harvested a wide variety of finfish species from the Hudson, many of which were documented by Mitchill (1815) who made numerous observations in the public markets. Among the species most heavily exploited in the 19th century were American shad and the two sturgeons. Sturgeons were valued for both their roe and flesh. Harvests were so great in the tidal Hudson that the fish was popularly known as “Albany beef,” because it was shipped upriver to a hungry market. Shad could be taken in great numbers in the spring spawning runs by stake- or driftnets, then salted for later consumption. In 1895, it was the number one inland fish harvested (Cheney 1896), valued at almost \$185,000 – equivalent to over \$3,900,000 today.

Both American shad and sturgeons were overharvested in the late 19th century. Because of its life history characteristics of late maturation and non-annual spawning, coast-wide overharvesting was inevitable, given the level of effort. Overharvesting of shad peaked in the 1890’s, with catches declining precipitously thereafter (Stevenson 1899). Writing in 1916, Dr. C.M. Blackford declared, “...there is probably no fish on earth that surpasses the shad in all the qualities that go to make up an ideal food fish...[but it] is the one whose preservation has become a national problem.” In the late 1800s, the Commission took the radical steps of (1) instituting a net lift period and (2) artificial propagation, which was the state-of-the-art in fisheries management at the time (for Hudson or U.S.?). Indeed, in June 1871, Seth Green, then one of the top fish culturists in the country, steam-trained across the country with delicate shad fry held in milk cans, discharging them into the upper Sacramento River (recounted in Boyle 1979). Shad became established on the Pacific coast, invading the Columbia River within 30 years (Ebbesmeyer and Hinrichsen 1997) and constituting an important, if exotic, component of the ichthyofauna there today.

Concurrent with turn-of-the-century overharvesting problems, a growing and rapidly industrializing New York City created serious pollution, with dumping of soot and garbage and discharges of wastes an ever-increasing nuisance. The oyster fisheries were essentially gone by the 1920s (Franz 1982), and the fouled water imparted an unpleasant flavor to most of the fishes (NYSCD 1964). Nevertheless, fisheries continued to constitute a livelihood, at least in part, for many throughout much of the 20th century

(Figure 1). With the enactment of the National Environmental Policy Act in 1970 and amended Clean Water Act in 1972, conventional pollution declined and in many aspects, the river recovered (Limburg et al. 1986). Nevertheless, as a result of widespread PCB contamination, several of the important commercial fisheries are closed, and today commercial effort is at an all-time low (see Shapley 2001 for a journalistic account).



Angling

The Hudson River estuary figures prominently in the history of American angling. Due in part to the high quality of fishing in its waters and to the many books and articles written about it, Zeisel (1990) considered New York City to have become the capital of American angling by 1850. Among the important angling writers were Frank Forester and Genio Scott. In his classic work, *Fishing in American Waters*, (Scott 1875) wrote about angling in the Hudson River estuary in the vicinity of New York City. Several sections were devoted to striped bass angling, including trolling for them from rowboats

in the “seething and hissing” waters of Hell Gate in the East River, a riptide where currents reached ten knots. Scott also described fishing for striped bass from rowboats near the hedges (fish weirs made from brush) in the Kill Van Kull and from bridges in the Harlem River. The Harlem River, although dammed for tidal mill power for the first half of the nineteenth century, was a major resort which offered excellent angling for striped bass, bluefish, weakfish, porgy, and flounder (Zeisel 1995).

These species, and others, were fished all over New York Harbor from shore and from rowboats. Zeisel (1995) quoted *Harper’s Weekly* of August 4, 1877, which stated that “On almost any day of the year except when the ice makes fishing impossible, hundreds of men and boys may be seen on the river front engaged in angling.” Zeisel (1990, 1995) also reported that in the mid-1800's, skiffs could be rented from various liveries and that during summer, hundreds of boats filled with anglers could be seen on the harbor’s best spots.

Angling in New York Harbor during Scott’s time included species almost never seen today. Scott provided instructions on exactly where and how to catch sheepshead near Jamaica Bay, an area where they were so abundant that farmers would fish them with hand-lines to supplement their income. Black drum, another twentieth century absentee, also were commonly landed during the previous century in Upper and New York Bays and the East and Harlem Rivers (Zeisel 1995).

A surprising category of fish that were caught in Upper New York Bay and along the docks of lower Manhattan from 1760 to 1895 was sharks (Zeisel 1990). Although their species identities remain unknown, large sharks were abundant in these inshore waters during that period, possibly drawn by large amounts of food refuse being disposed of in New York Harbor. Accounts exist (ca. 1815) of shark fishers catching as many as seven sharks at lengths of up to 14 feet at Manhattan’s Catherine Market (Zeisel 1990).

Fish along the shores of Manhattan began to taste contaminated from petroleum by the late 1800's, helping to push anglers to more distant waters such as the “fishing banks” in the New York Bight (Zeisel 1995). But angling farther upriver in the Hudson River developed more slowly. According to Zeisel (1995), fishing activity centered on wharves and docks at major landings such as the mouth of Rondout Creek in Kingston,

and at Newburgh, Poughkeepsie, and Hudson. Both shad and sturgeon roe were commonly used baits in the Hudson's freshwater reaches. Important species caught (mainly with hand-lines) included striped bass, white perch, American eel, and catfish. Tributaries of the Hudson River were also fished, particularly in spring for spawning runs of suckers and yellow perch. Many of these tributaries also supported trout, but this angling declined as they were fished out, with attention shifting to the black basses.

The endemicity in the Hudson River of one gamefish, Atlantic salmon, has been debated since Robert Juet—a member of Henry Hudson's exploratory expedition up the river—reported “many Salmons and Mulletts and Rays very great.” This notion was fueled by their occasional capture by net in the river throughout the nineteenth century. However, a number of scientists have concluded that the Hudson did not support a salmon population and that such appearances were probably strays from neighboring systems such as the Connecticut River. Nonetheless, Atlantic salmon eggs from Penobscot River specimens were stocked in the Hudson River in the 1880's (Zeisel 1995). These stockings were sufficient to result in hundreds of commercial catches in the lower river and fewer via angling upriver, chiefly at Mechanicville (following collapse of a dam at Troy). However, there is no evidence that natural reproduction occurred and this fishery dwindled after stocking was halted. Given that Juet's observation was made in September in Lower New York Bay and because of its superficial salmonid resemblances, it is likely that he mistook weakfish for salmon.

Fishing clubs became numerous along the Hudson River beginning in the late 1800's (Zeisel 1995). They led the fight against the Hudson fishing license, which was in effect from the 1930's to 1946. Inasmuch as it was instituted during the Depression and was costly, many people ignored it as they angled for sustenance. Game wardens were overwhelmed and judges dismissed cases against destitute offenders, which together with the fact that the river was not stocked by the state with fish, eventually led to its repeal.

Angling on the Hudson River estuary continued without fanfare during the early to mid-1900's. But because of its severe sewage and industrial contamination, the estuary appears to have reached a nadir in angling activity over that period.

The Current Regulatory Framework

Hudson River fisheries are managed by the New York State Department of Environmental Conservation (DEC). Regulatory capacity lies within the Division of Fish, Wildlife and Marine Resources. For anadromous fish species in the Hudson and in marine waters, state regulations for commercial and recreational fishing follow guidelines set by Interstate Fishery Management Plans developed through the Atlantic States Marine Fisheries Commission (ASMFC). The ASMFC is a federal commission created to coordinate cooperative management of shared coastal resources for the fifteen coastal states from Maine to Florida, along with the two federal resource agencies, the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS). As set forth in its mission statement (ASMFC 2002), *“With the recognition that fish do not adhere to political boundaries, the states formed an Interstate Compact, which was approved by the U.S. Congress. The states have found that their mutual interest in sustaining healthy coastal fishery resources is best achieved by working together cooperatively, in collaboration with the federal government. Through this approach, the states uphold their collective fisheries management responsibilities in a cost effective, timely, and responsive fashion.”*

A number of important laws underpin fishery management in the

Hudson (see side box, “Milestones in Fisheries Legislation”). The Anadromous Fish Conservation Act provides authority and funding for preservation and restoration of anadromous fisheries, and was the impetus for much-needed research on biology, life history, population status, and characteristics of fisheries. The Fishery Conservation and Management Act of 1976, known as the Magnuson Act, created a 200-mile Exclusive Economic Zone (EEZ) along the U.S. coast, enabling controlled fishing in U.S. territorial waters. Fishing in the EEZ is regulated by regional management councils and NMFS.

Milestones in Fisheries Legislation

1965	Anadromous Fish Conservation Act
1976	Fishery Conservation and Management Act (Magnuson Act)
1979	Emergency Striped Bass Study (sub-set of AFCA)
1984	Atlantic Striped Bass Act
1993	Atlantic Coastal Fisheries Cooperative Management Act
1996	Sustainable Fisheries Act
1996	Magnuson-Stevens Fishery Conservation and Management Act

State jurisdiction is defined as 0-3 miles, and is coordinated through the ASMFC. The Sustainable Fisheries Act and the Magnuson-Stevens Act of 1996 evolved from the Magnuson Act. In particular, Magnuson-Stevens changed emphasis to include protection of aquatic habitats, to focus on optimum sustained yield that took account of “relevant social, economic, or ecological factor[s],” and mechanisms to reduce the risk of decision-making by vested interests (Ross 1997).

The Emergency Striped Bass Study of 1979 and the Atlantic Striped Bass Act of 1984 responded to dramatic declines in catches of striped bass, particularly in the Chesapeake Bay. The ESBS increased coast-wide research and monitoring for striped bass stocks, and the ASBA, as a follow-on, required mandatory compliance with the Interstate Fishery Management Plan for striped bass. Finally, the Atlantic Coastal Fisheries Cooperative Management Act, modeled on the ASBA, provides a regulatory framework for all species managed through the ASFMC. A Fishery Management Plan (FMP) must be developed for each species, and fisheries must be monitored by each member state.

Profiles of Significant Hudson River Fisheries Stocks

In this section, we describe recent trends and status of the major commercial fishery species in the Hudson.

Striped bass: a “success” story of interstate cooperative management.

In the years prior to 1982, few restrictions governed the take of striped bass in state and coastal marine waters. Size limits were minimal, if non-existent. In New York waters, fish as small as 16 inches fork length (FL, equivalent to 40.6 cm) could be taken, there existed limited seasonal and gear restrictions, and there

was no catch limit. The small size limits allowed few striped bass to reach maturity. Most females reach spawning age at six years of age, with over 97% spawning by age eight. These fish are in the size range of 24 to 28 inches (61 to 71 cm; see side box).

Striped bass live approximately 25 to 30 years.

<u>Sex</u>	<u>Age at Maturity</u>	<u>Size</u>
Male	3 to 6	16 to 24 in
Female	6 to 8	27 to 32 inches

Migratory range: Canada, New England, and mid Atlantic coasts

In the Chesapeake Bay, the striped bass fishery focused on “panfish” with fish as small as 12 to 14 inches (30.5 to 35.6 cm) making up most of the harvest. Over the course of roughly 15 years from the 1970s through the early 1980s, few adult spawners returned to the Bay. With the collapse of the Chesapeake stock in the mid-1970s, states realized that it would take a concerted, cooperative effort to restore the Chesapeake population. To achieve this goal, the Emergency Striped Bass Act (part of the Anadromous Fish Conservation Act) was passed by the US Congress in 1979. This new federal law required all coastal states that harvested striped bass to follow management regulations contained in the newly developed fishery management plan. Management would no longer be by voluntary agreement, but rather by enforced compliance. The enforcement for non-compliance is complete closure of an entire state’s fishery for that species. The first striped bass fisheries management plan (FMP) was adopted by ASMFC in 1981.

Over the course of the next fifteen years, management regulations followed an adaptive process, and the FMP was amended five times. The most severe restrictions occurred in Maryland where a moratorium on striped bass fishing was implemented in Chesapeake Bay. Marine commercial fisheries were limited by severely reduced quotas to less than 20% of historical harvest levels, and season, size limits, and allowable gears were specified and enforced. Recreational fisheries were limited by size and bag limits, and by seasons. These regulations, especially size limits, were adjusted annually from 1984 until 1990, from 24 to up to 38 inches (61 to 96.5 cm), to protect the females from the 1982 year class (young fish produced) of the Chesapeake Bay until most of them spawned at age 8.

The effect of these regulations was startling, not only for the Chesapeake stock, but for other striped bass stocks along the coast. The coastal protective measures immediately protected immature fish of the Hudson spawning stock of striped bass. Hudson River striped bass may leave the estuary as early as age one to seasonally utilize the nearshore ocean. Prior to adoption of the FMP, recreational and commercial fisheries alike exploited these immature bass. Once fish were no longer harvested at 16 inches, the increasing coastal size limits gave refuge to the Hudson’s immature and mature

population. The effect was the return of greater numbers of older, larger fish each year (Figure 2), which in turn produced ever greater numbers of young.

By 1995, coast-wide management targets were being met: striped bass were returning to the rivers to spawn, production estimates were up, and adult age structure was stabilized. It was then that the Chesapeake stock was declared restored. The state management agencies were not complacent about their success. Even with record numbers of fish, management restrictions were loosened slowly. Commercial harvest quotas were increased, and recreational size limits were lowered to 28 inches.

Annual tracking of mortality rate of the stock is still key. Harvest from all sources is compiled annually. Spawning stocks are monitored for age structure and survival. Young-of-year abundance estimates provide early warning of changes that may come.

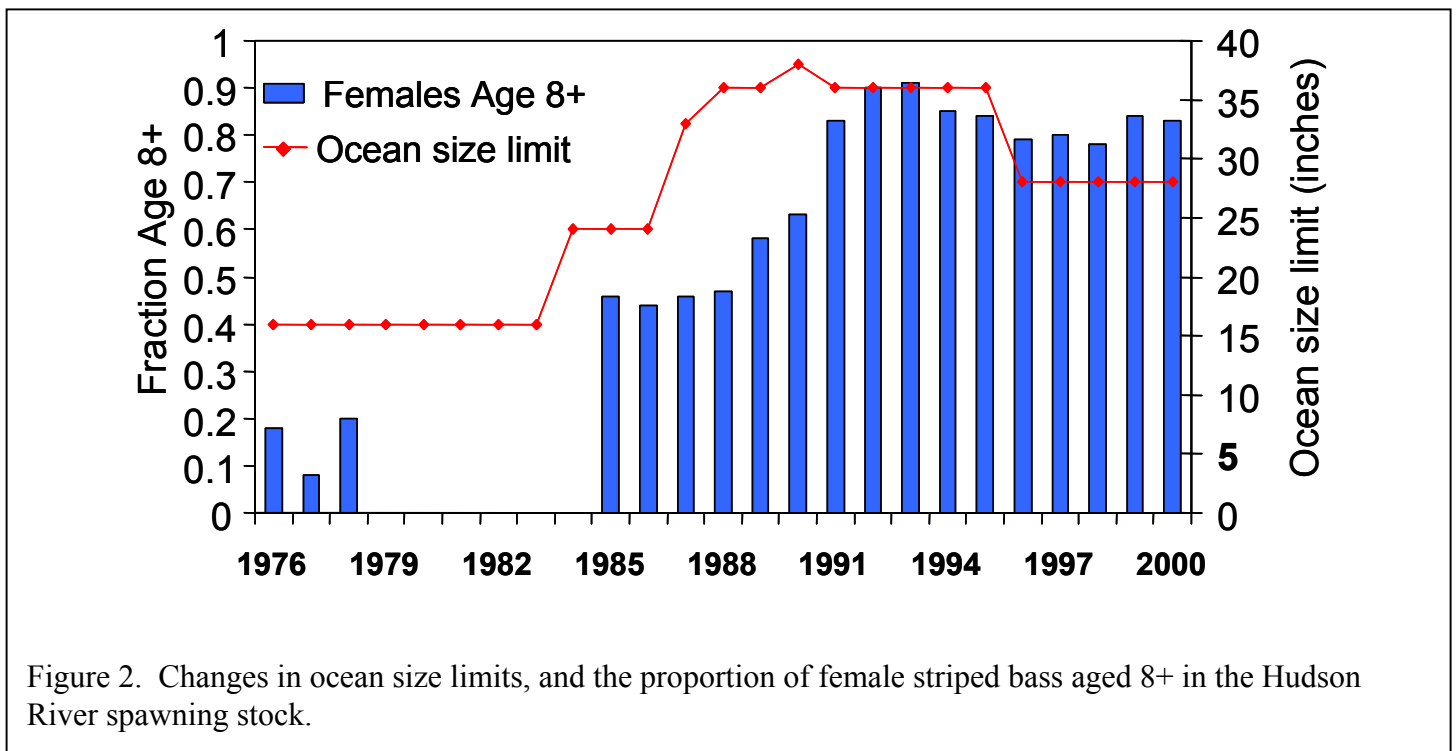
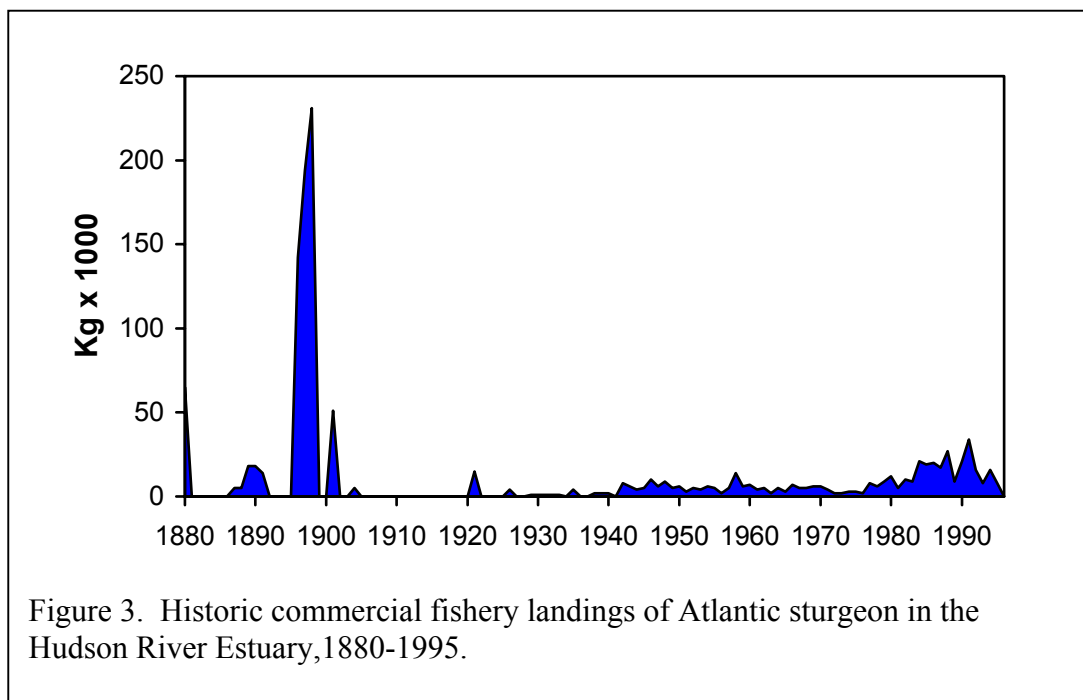


Figure 2. Changes in ocean size limits, and the proportion of female striped bass aged 8+ in the Hudson River spawning stock.

Atlantic sturgeon

Records of sturgeon harvest are available as far back as the 1880s, a time when harvest levels climbed to record highs. The high harvest level essentially clear-cut the once robust population. The Hudson's Atlantic sturgeon stock continued to remain severely depressed through the rest of the 20th century (Figure 3).

Atlantic sturgeon live approximately 60 to 80 years. Males mature by age 8 to 12 and 15 to 20 years for females. Females spawn every three years. **Migratory range:** entire Atlantic coast, ME to FL



A vestigial fishery persisted in the River through the 1980s, made up of a small group of fishers taking a few fish each year for their caviar and meat. However, interest in this fishery began to change in the late 1980s. Elsewhere on the East coast, other Atlantic sturgeon stocks had already been over-fished and harvest restricted or eliminated. The most important were those that targeted sturgeon produced in the rivers of North Carolina, South Carolina, and Georgia (Smith 1985). These fisheries stimulated a market demand for smoked sturgeon products as the supply was eliminated through regulation of harvest. In ocean waters, interest rose in the late 1980s targeting the

immature sturgeon for the smoked meat market, especially in New York and New Jersey (Waldman et al. 1996).

This market shift occurred while the restrictions in striped bass management were taking hold along the Atlantic coast. Atlantic sturgeon was among the species that became fishing targets to make up for lost income. In addition, import restrictions from the Middle East (Iran was a source of much of the caviar available in the U.S.) greatly enhanced the value of any domestic source of caviar. Some of the Hudson's shad fishers began to experiment and eventually became very successful at capturing adult Atlantic sturgeon.

Based on the success of rebuilding the striped bass stocks, the Atlantic Coastal Fisheries Cooperative Management Act was passed in December 1993. This act gave the same stringent enforcement power to all FMPs developed under ASMFC. States, with New York in the lead, began to look with much scrutiny at the condition of the River's Atlantic sturgeon stock and the rate they were being fished.

With their long lifetime, older age at maturity, and irregular spawning schedules, Atlantic sturgeon are easily over-fished. Young fish were being harvested in coastal waters as they left the Hudson at age three to seven to begin their long ocean residence before they mature ten to 15 years later. Few fish were surviving to return to the River, and even here a fishery targeted the spawning adults. In 1995, New York tried to implement controls in the fishery with season and area closures, followed in 1996 with the imposition of a quota system, limiting the total amount of take. But by 1997, New York's stock assessment results bore out the facts that harvest and fishing rates were severely over the limit that the population could handle. A moratorium was put in place that year, and by 1998 the entire U.S. Atlantic coast was closed to harvest. The interstate management plan set a 40-year time limit for the coast-wide moratorium based on the life history of the animal. That is, within the next 40 years, the current spawning population's young should be able to grow and mature to produce one more generation before examining the re-opening of any fishery.

American Shad

At the turn of the 20th century, the new immigrant population continued to swell the growing Atlantic coast cities, including New York. It amazed them to find that every spring fish returned to the Hudson by the thousands, an easy food supply to feed the hungry. Unfortunately for shad, it earned recognition as the second highest harvested fish on the east coast following Atlantic cod. Atlantic sturgeon came in third. The seemingly unlimited harvest, however, wore down the stock, and before long shad suffered the same fate in the Hudson as in other Atlantic coast rivers.

<p><i>American shad</i> in the Hudson River live 13 to 15 years. Males begin to spawn by age 3 to 5, females by age 5 to 7. Migratory range of Hudson shad: upper half of the Atlantic coast, Maine to Virginia</p>
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The story of respite, rebuild, over-harvest, and collapse occurred several times for the Hudson shad stock (Hattala and Kahnle 1997). During periods of lowered fishing pressure, the stock re-built between collapses. However, the resiliency of this highly fecund species was slowly being eroded as the century wore on. The first collapse occurred prior to the known record. United States Fish Commission reports documented that in the 1870s the Hudson stock was “over-fished and in need of replenishment.” Seth Green, then working for New York State, began a hatchery to stock shad in the spawning areas in the upper reaches of the tidal Hudson and even above the Troy Dam (Cheney 1895). Fishing was not the only problem for the stock. Spawning areas were lost as the shallow bays behind the River’s islands were slowly filled with dredge spoil from creation of a shipping channel to the Port of Albany. Nearly a third of the upper tidal Hudson was filled, almost all of it shad spawning habitat. Water quality in the spawning reach also suffered through much of the 20th century (Faigenbaum 1937, Burdick 1954, Talbot 1954, Boyle 1979) until improvements to sewage treatment were made.

The gaps in the fishery landings records from the early 1900s (Figure 4) are thought to be from lack of fishing activity. This lack of fishing would have allowed the shad stock to rebuild to a size necessary to produce the dramatically large harvest that occurred during the years leading up to World War II. Fishing this available food source became a valued trade during the war, so much so that fishing rules in the river were

suspended. Each spring in the war period, hundreds of fishermen set their nets, and riverside communities took as many fish as the nets could bear.

In less than 12 years, the next stock collapse was underway: the greater the effort, the fewer the fish. In addition, water quality worsened. Sewage poured in and habitat suffered. In the summer, sections of the river, around Albany and the lower estuary, were completely devoid of oxygen. A few shad kept returning, but the overall stock size remained much reduced from its former status. This problem was not unique to the Hudson: for example, the Delaware River was so polluted between Trenton and Philadelphia that this entire segment went anoxic in the summer months, preventing any movement of fish, such as migrating shad (Chittenden 1969).

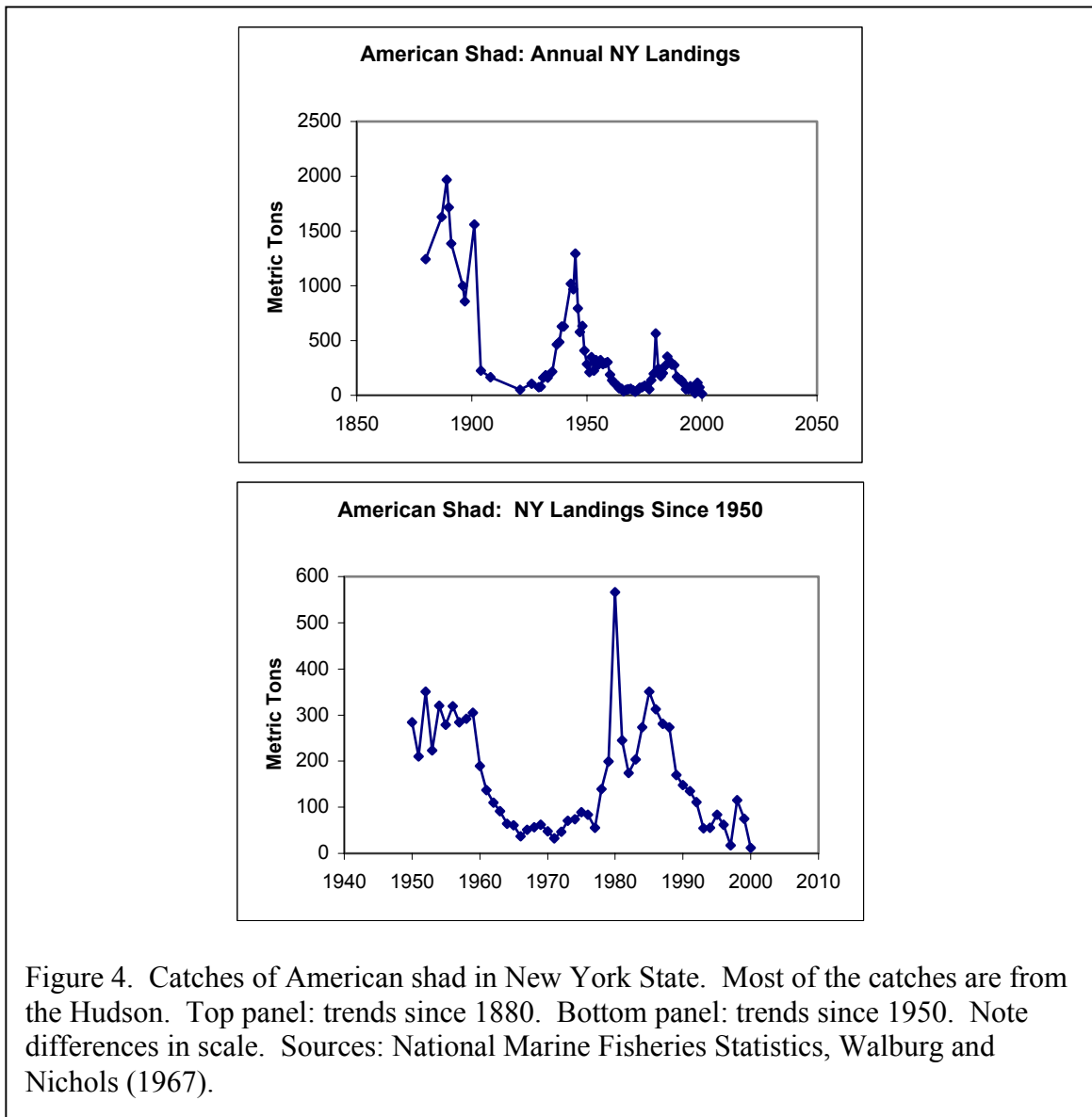


Figure 4. Catches of American shad in New York State. Most of the catches are from the Hudson. Top panel: trends since 1880. Bottom panel: trends since 1950. Note differences in scale. Sources: National Marine Fisheries Statistics, Walburg and Nichols (1967).

Finally in the mid 1970s, the environmental movement gained much momentum. With the passage of the much-strengthened amendments of the Clean Water Act in 1972, the sewage dumping eventually abated. The River slowly started to gain again, along with its fisheries.

Humanity’s influence again was felt, just as in the case of Atlantic sturgeon. During the recovery effort for striped bass, many near-shore ocean fishers shifted their focus to American shad. These “ocean intercept” fisheries directed their fishing pressure onto all the east coast shad stocks, including the Hudson’s. Some stocks began to show declines, or no sign of recovery, despite numerous restoration programs. Since 1991, the

Hudson's shad stock began its latest decline, showing classic signs of over-fishing. Fish are smaller at any given age, and fewer older fish are returning to spawn.

Closure of the directed ocean intercept fishery is scheduled for 2005, with the first 40% reduction in effort in 2003. How effective will this measure be? At this point, it is unclear how quickly the stocks will respond to the reduced harvest. Directed fishing may come to an end, but in some cases, shad picked up in other fisheries may become discarded bycatch. Continued monitoring of this bycatch will be a key element in managing the coast-wide restoration. In the Hudson River, it is still unknown whether further cutbacks will be required, for example, closure of more spawning area, or lengthening the lift (no fishing) period.

Contemporary Angling and the Sport Fishery

With the general upgrading of sewage treatment during the twentieth century and, particularly since passage of a New York State Bond Act in 1965 and the federal Clean Water Act amendments of 1972, the Hudson River and New York Harbor have seen recoveries of many fish populations (Waldman 1999). The increased availability of fish and a growing perception that the Hudson River system has become cleaner has led to a pronounced increase in angling activity. However, this increase has not been well quantified due to the rarity and limited scope of angling surveys conducted, and to potential knowledge lost through consideration of the mainstem tidal Hudson River as an extension of the sea for which fishing licenses are not required. Moreover, despite this angling revival, its enjoyment is hindered by the continuing presence of PCBs and other contaminants in the river's finfish and shellfish and in resultant governmental restrictions and health advisories.

Boyle (1979) contrasted the intense angling effort for striped bass in the mid-1900's along the ocean coast with the dearth of striped bass anglers in the Hudson River, despite the species' high abundance in the river. Boyle wrote: "...only a relative handful of anglers, perhaps fifty at best, regularly take advantage of the striper fishing that is to be had in the Hudson." He also described the Albany Pool as being "so awesomely foul as to be a source of wonder to sanitary engineers" from raw sewage releases and that this

caused the river to be essentially devoid of oxygen in summer for twenty to thirty miles south of the federal dam at Troy.

But in the last two decades of the twentieth century, as the Hudson River reached levels of purity not seen for decades to a century or more and the striped bass population continued to increase, angling over the length of the tidal river grew in popularity, with the area below the federal dam becoming especially attractive as striped bass and other anadromous fish aggregated there in large numbers (Lake 1985, Zeisel 1995). A snapshot of this emergent striped bass fishery in 1997 between the George Washington Bridge and the federal dam was provided by Peterson (1998). Using a combination of 37 aerial flights and 2,700 angler interviews from April through June, he estimated the striped bass fishery supported 619,132 angler-hours distributed over 145,842 angler-trips. Of these, the boat fishery was responsible for 71% of effort and 84% of catch. Total catch was estimated at 112,757 striped bass, of which only 12.5% were harvested. This low harvest was attributed to concerns over PCB contamination and to restrictive bag limits (one fish 18 inches or larger north of George Washington Bridge; one fish 28 inches or larger south of George Washington Bridge). This fishery in the Hudson River and New York Harbor became so popular that several, mainly springtime charter boat operations were launched (Vargo 1995, Waldman 1999), and annual tournaments are now held. Accounts of urban angling for striped bass in New York Harbor may be found in Waldman (1998, 1999).

Another fishery that has grown from one enjoyed by relatively few local residents in the mid-1970's to one that supports charter boats and tournaments that garner national publicity is for the two black basses of the river: largemouth and smallmouth bass (Nack et al. 1993). These species occur in freshwater and low salinity reaches of the river. Recruitment in the Hudson River is low for black basses but growth is rapid (the fastest in New York State, Green et al. 1988), resulting in a fishery that is attractive because it provides a high percentage of large specimens despite low densities of adults (<2 largemouth bass per hectare, Carlson 1992). Moreover, these fisheries are primarily catch-and-release, with considerable effort spent in tournaments or practicing for tournaments; Green and Jackson (1991) estimated that as of 1990, there were 50-60 black

bass tournaments held annually in the river. This tournament activity is centered in Catskill (Green et al. 1993).

There is concern over the effects of tournaments on the Hudson River black bass population. Green et al. (1993) estimated that during 1989-1991 at least 10% of the river's largemouth bass were weighed in during summer. Increased handling, especially during warm conditions, may lead to greater mortality. Although cause and effect was not demonstrated, the estimated population size of largemouth bass (>280 mm) declined from 22,000 in 1989 to 14,000 in 1991. On the other hand, more recent estimates of populations indicate that largemouth were back up to 22,000 by 2000 (LMS 2001). Smallmouth bass abundance was estimated at 5,000 - 6,000 (LMS 2001). Tournament intensity was lower in 1999 and 2000 compared to surveys conducted in the late 1980s, and the catch rate for largemouth bass in 2000 was the highest on record (LMS 2001).

Ironically, a new sport fishery has developed for American shad in the Hudson River as they continue their long-term decline there. Anglers have learned that in addition to below the federal dam where shad aggregate, they may also be found by targeting particular types of habitat and tidal stages throughout much of the tidal freshwater portion of the river (NYSDEC 1982).

Several angling surveys have occurred that stemmed from health concerns about fish consumption but that nonetheless provided ancillary information on the nature of the fishery. Belton et al. (1986) surveyed anglers in the lower Hudson River, Upper New York Bay, and Newark Bay between 1983 and 1985. Young-of-the-year bluefish made up 85% of the observed finfish catch, with larger bluefish, striped bass, summer flounder, and winter flounder also prominent. Blue crab was heavily fished and was the most frequent species consumed. Two-thirds of respondents who admitted eating their catches considered them to be totally safe to eat and about one-fifth viewed them as slightly polluted but not harmful.

Another factor that contributed to a recent increase in angling activity in the Hudson River is the development of shoreline access. Many communities have opened shorelines, piers, and bulkheads to fishing with the help of directed funding such as the

Hudson River Improvement Fund. New York City has constructed piers for angling at several sites.

Conflicts with Fisheries

As seen throughout the pages of this book, the Hudson River is many things to many people. So far we have reviewed the conflict between the River as food production base and sewage recipient. We now discuss, briefly, two other anthropogenic activities potentially at odds with sustainable fisheries: power generation and toxicants. For more detail on background, see Limburg et al. (1986) and Baker et al ([this book?](#)).

Water withdrawal by electric power plants

Until recently, a consortium of public utility companies (Consolidated Edison of New York, Orange and Rockland Utilities, Central Hudson Gas and Electric, New York Power Authority, and Niagara-Mohawk) owned and operated seven generating stations ranging from 59th Street on Manhattan to Albany (Table 1). The plants are under new ownership as a result of industry deregulation. All of the plants use Hudson River water as coolant, and recycle the water back to the River. These plants have a combined rating of 5,905 Mwe, but more relevant here, a combined total cooling water flow exceeding 23,465,000 m³ per day. This flow is on par with freshwater discharges measured at Green Island, where the average annual discharge (1918-1980) is 44% higher, but where mean August flows are 42% lower (Limburg et al. 1986).

Table 1. Current power plants along the tidal Hudson River. Data from Limburg et al. (1986) and updated.

Name of Facility	Initial year of operation	Original operator	Current operator	Location (km from Battery)	Total gross rated capacity (Mwe)	Total cooling water flow (1000 m ³ /d)	Fuel type
Albany Units 1-4	1952-1952	Niagara Mohawk		229	400	1,921	Fossil
Danskammer 1-4	1951-1967	Central Hudson	Dynegy	107	480	1,725	Fossil
Roseton 1 & 2	1974	Central Hudson	Dynegy	106	1248	3,496	Fossil
Indian Point 2	1973	Con Edison	Entergy	69	906	4,746	Nuclear
Indian Point 3	1976	NY Power Auth.	Entergy	69	1000	4,746	Nuclear
Lovett 1-5	1949-1969	Orange & Rockland	Mirant	68	496	1,725	Fossil
Bowline 1 & 2	1972-1974	Orange & Rockland	Mirant	60	1244	4,189	Fossil
59th Street, NYC	1918	Con Edison	Entergy	8	132	917	Fossil

Initial concern about potential impacts of power plants was that the heated effluent would cause harm to the biota, but it was soon seen that the larger potential threat was direct mortality due to two factors: entrainment, or the passage of small organisms, particularly fish larvae, through the plants and across the heated turbines; and impingement, or the trapping of fish on intake screens designed to keep large particles out of the cooling water inlets. Gradually, attention focused mostly on the potential impacts of the power plants on a few “representative and important species,” but primarily on striped bass.

Between 1974 and 1980, a protracted series of hearings and litigations by a group of plaintiffs consisting of government agencies and environmental organizations examined the utilities’ environmental impact statements. During these hearings, increasingly complex mathematical models were developed to describe the potential losses of key species, especially striped bass, as a result of entrainment and impingement. At the same time, data were collected in several major programs, all funded by the utilities and continuing today. These are the Long River Survey, designed to assess egg and larval densities; the Fall Shoals Survey, to assess juvenile densities off shore; and the Beach Seine Survey, designed to assess onshore fish communities and abundance. It was determined through statistical analysis of the data sets that the level of variation in the data obscured any clear forecasting of the impacts of the plants, and that it might take as long as 50 yr of data collection to observe any clear trends (Limburg et al. 1986). With no foreseeable scientific determination, all the parties to the litigation entered into a negotiated settlement, lasting from 1980-1990, that prescribed outage (period of reduced water use) schedules to reduce larval mortality, modifications of intake screens, and the establishment of an institution (The Hudson River Foundation) to provide secure funding for future Hudson River studies.

During the 12 years since the Hudson River Settlement Agreement expired, the utility companies continued to monitor fish communities and produce annual reports. In addition, they prepared a new draft environmental impact statement (DEIS 1999). In the meantime, the Federal government deregulated the power industry, and over the past few years all the utilities have been purchased by private corporations (Table 1). Additionally another five new-generation power plants have sought approval for construction along

the Hudson. The new plants will use only a fraction of the water and will be closed-cycle, i.e., will use cooling towers rather than returning thermal effluent to the river.

The socioeconomic climate for operating utilities along the Hudson appears to have changed; deregulation's intent was to produce more competition, and a potential side effect is that the companies operating the existing plants are less concerned with environmental effects than the previous owners. However, the new owners inherited the environmental issues of operating the old plants, and these are still in need of resolution. Among the issues that will likely be contested in future hearings are whether or not fish populations (particularly striped bass) have "compensatory mortality," or the ability to rebound at low densities, as when depleted by power plant mortality; whether bay anchovy, an important estuarine forage species that suffers up to 50% year class removal by the plants, truly constitutes a Hudson River population or is part of a larger, offshore stock; and whether the power plants affect species that experience other environmental stresses, for instance, Atlantic tomcod that has been stressed due to a long-term warming trend in the River.

PCBs and other toxicants

Toxic substance contamination is widespread in the Hudson and is covered in other chapters. It has had a fundamental impact on fisheries here, as well as throughout New York State. Fish commonly angled in the Upper and Lower Hudson contain 10-fold greater levels of PCBs than Great Lakes fish, and these levels are two orders of magnitude greater than found in Chesapeake Bay (Baker et al. 2001 white paper – or included in this book?).

The Food and Drug Administration (FDA) prohibits the interstate sale of contaminated products. FDA guidelines on selected toxic substances are given in Table 2. Note that for PCBs, the action level of 2 ppm is now considered by many to be too high, and many states are adopting more stringent guidelines. This has translated into the closure of commercial fisheries for striped bass since 1976, some of which do remain for many years in the Hudson and build up elevated body burdens of PCBs (Zlokovitz and Secor 1999). Other species for which smaller commercial fisheries existed include eels, bullhead, and carp, all of which currently contain high levels of PCBs and other

contaminants. According to data from Skinner et al. (1996, 1997), striped bass also exceed the action limits on mercury and dioxin, eels do so on PCBs, DDT, dioxin, and chlordane, and white perch has concentrations above the action limit for chlordane.

Table 2. FDA guidelines on maximum allowable levels of selected contaminants in fish. Source: FDA 1999.

Substance	Level	Food type
Aldrin, Dieldrin	0.3 ppm	all fish
Chlordane	0.3 ppm	all fish
DDT, TDE, DDE	5.0 ppm	all fish
Heptachlor	0.3 ppm	all fish
Mirex	0.1 ppm	all fish
PCBs	2.0 ppm	all fish
2,4-D	1.0 ppm	all fish
Arsenic	76 ppm	crustaceans
	86 ppm	molluscan bivalves
Cadmium	3 ppm	crustaceans
	4 ppm	molluscan bivalves
Chromium	12 ppm	crustaceans
	13 ppm	molluscan bivalves
Lead	1.5 ppm	crustaceans
	1.7 ppm	molluscan bivalves
Methyl mercury	1 ppm	all fish
Nickel	70 ppm	crustaceans
	80 ppm	molluscan bivalves

Although crustaceans bioaccumulate high levels of metals and organochlorines in their hepatopancreas, their muscle tissue is very low in contaminants, and hence fisheries persist with the caveat that hepatopancreas, or “tomalley,” should be discarded. The only other commercial fisheries that persist are for American shad and river herring which as adults only return to the Hudson to spawn, and therefore have low contaminant burdens. River herring are sold as bait to striped bass sport fishers. Ironically, the increase of striped bass that cannot be kept and sold commercially has driven some of the few remaining commercial fishers to give up, because the nets become full with striped bass and must be laboriously picked out without profit.

Since the awareness of widespread contamination in the 1970s, the New York State Health Department and the DEC both issue annual health advisories against eating certain fish from particular waters, including many specific areas within the Hudson drainage. Nevertheless, angler surveys indicate that the message does not always get through to the fishers. A survey by Barclay (1993) interviewed anglers in 1991 and 1992 at 20 shorefront locations from Fort Edward to New York Harbor. Survey respondents were predominantly male (92%) and 84% were between the ages of 15 and 59. Two-thirds of the anglers were Caucasian-American, 21% were African American, and 10% were Hispanic American (others were 2%). Barclay found that almost one-fifth (18%) of the anglers who eat their catch were trying to catch blue crabs, whereas another 23% indicated they were not targeting any particular species. Of those who eat their catches, only 48% were aware of health advisories. Fish consumption varied by ethnicity; 94% of Hispanic American, 77% of African American, and 47% of Caucasian American anglers ate their catches. During 1995 in a New Jersey portion of New York Harbor, Burger et al. (1999) found there were ethnic differences in consumption rates, sources of information about fishing, knowledge about the safety of the fish, awareness of fishing advisories, and knowledge about health risks.

Most recently, in 1996, NYSDOH (2000) surveyed shoreline-based anglers on the Hudson River between Hudson Falls and Tarrytown, New York; the protocol of this survey was similar to that of Barclay (1993). Three regions were defined: Area 1, from Hudson Falls to the Federal dam at Troy; Area 2, from the federal dam to Catskill; and Area 3, from Catskill to Tarrytown. Because of high levels of PCB contamination, angling in Area 1 during 1996 was catch-and-release only. In both the Barclay (1993) and NYSDOH (2000) surveys, more than 90% of anglers said they were fishing primarily for recreation or other similar reasons, and only 6-7% said they were fishing primarily for food. In 1996, about one-third of anglers surveyed had kept at least some of the fish they caught from the river.

The most numerous catches were of white perch and blue crab, with striped bass, white catfish, and American eel also frequent (NYSDOH 2000). But species most commonly kept (by total weight and in order) were white perch, white catfish, striped bass, and carp. Together with the two black basses, bluefish, and American eel, these

eight species accounted for 83% by weight of the fish observed to have been harvested in this survey. NYSDOH (2000) concluded that numerous anglers in Area 3 remained unaware of health advisories for consumption of fish from the Hudson River. This is likely because anglers fishing the lower Hudson are not required to purchase licenses, and the health advisories are included in the state's fishery regulations booklet given out with the license.

The landmark decision by the U.S. Environmental Protection Agency in 2000, and upheld by Director Whitman in August 2001 (Johnson 2001), is to enforce a dredging order that will require sediments from a 10-mile (16 km) stretch of the Upper Hudson to be removed. These contaminated sediments have been shown to be the greatest continuing source of PCB contamination for fish in the River and Estuary. As Baker et al. (2001 or in this book?) point out, such a massive project will require careful execution and monitoring, but the resulting lowering of PCB concentrations in fish should be rapid following project completion. This will have the immediate effect of permitting consumption of many currently inedible species.

The future of fisheries in the Hudson

It is difficult enough to forecast catches from one year to the next for a single species, and virtually impossible to predict the future of Hudson River multi-species fisheries over the long term with any sort of accuracy. Nevertheless, we can comment on some trends.

Commercial fishing is in long-term decline, in the Hudson and many other east coast estuaries. If the status quo were to remain, the future would not look optimistic. However, the restoration of striped bass through a concerted, interstate management program demonstrates that overexploited species can be brought back, and restoration programs are under way for American shad, river herring, and sturgeon in many of the same systems. Fishery management programs in the Hudson use a combination of regulatory instruments (closures, seasons, and limits on minimum size, numbers caught, etc), focusing on regeneration of a natural stock rather than through hatchery supplementation, although such programs are ongoing in a number of East coast states.

Further, a number of inter-agency programs are working to remove toxicants from the River and reduce the inputs. Beside the EPA's PCB removal project in the Upper Hudson, programs such as the Contaminant Assessment and Remediation Project, part of the New York-New Jersey Harbor Estuary Program, are identifying the fate and transport of contaminants in order to remove them. Although serious problems still exist in the Harbor region, improvements have been noted (Steinberg et al. 2002).

Whereas commercial fisheries have diminished in the River, recreational fishing has increased to unprecedented levels. The restoration of striped bass stimulated a wave of angling interest, and sport fishers throng the Hudson during the stripers' spawning season. The projected toxicant cleanups will benefit all users of the resources, including users of striped bass. However, the conflict between sport and commercial resource users of striped bass may widen, unless both can come to an understanding on how management allows sharing of this common resource, as it occurs in marine waters along the entire mid-Atlantic coast. Recreational angling contributes to local economies, but so do commercial fisheries to a lesser, and some think, unimportant degree. But there are non-economic impacts of cultural value in preserving the heritage of commercial fisheries, as well as in promoting stewardship of the resource by all users.

Overlain on the patterns of human alteration of fish stocks and their habitats is the prospect of fundamental climate change, resulting in a warmer Hudson River. Already we may be seeing evidence of this. Rainbow smelt and Atlantic tomcod, both northern boreal species at the southern extent of their range in the Hudson, are disappearing. Smelt have not appeared in utilities' or state fisheries surveys since the mid-1990s, and tomcod have declined dramatically and appear to be cycling between moderately and very low abundances (DEIS 1999). On the other hand, gizzard shad, a species known from the Mississippi and southeastern drainages, appears to be increasing dramatically in the Hudson, and is also appearing in estuaries as far north as Maine. Gizzard shad has potential to become a strong ecological actor in the Hudson fish community, because it can compete for zooplankton effectively, rapidly outgrow its "window of vulnerability" to predation, and can then subsist on detritus and thus not be food limited. How these and other changes in the dynamic fish community will affect fisheries is a research question, but clearly they will have an impact.

The long-term patterns seen in fisheries statistics, and especially the more intensive monitoring studies of the past 20-30 years, have taught us much about the dynamics of Hudson River fish stocks, what is possible to know (e.g., spawning stock characteristics such as age and size distributions) and what may never be possible to know precisely (e.g., absolute stock abundances). In many respects, we now have the tools available for sustainable fisheries management. The critical element needed to carry through is strong public and political commitment of resources for continued adaptive assessment and management.

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