

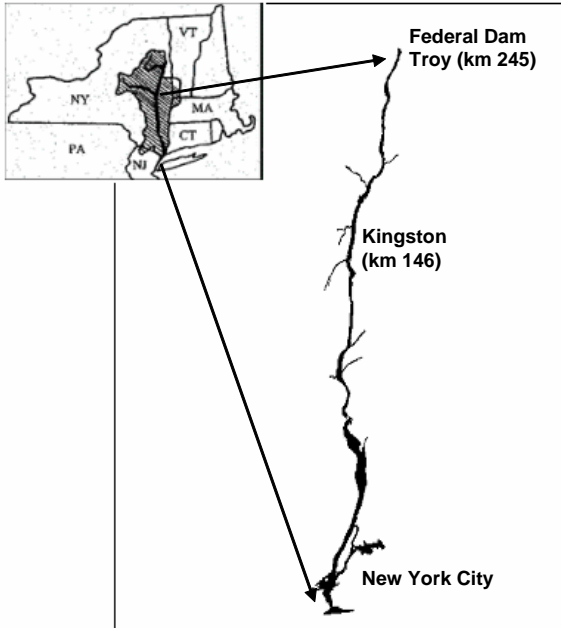


## Status of American Shad in the Hudson River, New York\*

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### Distribution, Biology and Management



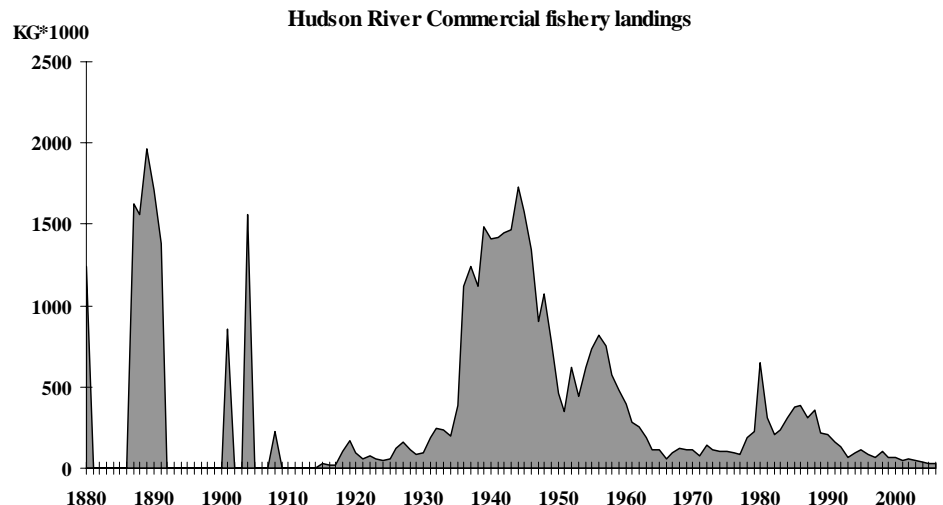
Anadromous fish have been harvested from the Hudson River since the 1600s when the Dutch first colonized the valley. The immigrants brought with them the skill and tools of fishing, and learned from the Native Americans about the numerous fish that arrived every spring. Regulation of the fishery came early, beginning in the mid 1800s. Gear restrictions and the first of the escapement periods were created by the New York legislature in 1868. The Hudson River was also the location of the one of the first American shad hatcheries on the Atlantic coast. Seth Green, a New York fish commissioner and conservationist, worked with Federal biologists, of the then U.S. Bureau of Fisheries, to promote stocking shad to reverse perceived declines in shad stocks on the mid-Atlantic coast. Despite these efforts, the Hudson River American shad stock's demise continued because of repeated overfishing complicated by habitat alteration and pollution that continued for nearly 140 years.

The Hudson is a highly productive system. It is tidal for 254 km to the first impassable barrier. Shad spawn in fresh water in the upper two-thirds of river above Kingston, New York. Females return to spawn from age four through six, males ages three through five. After spawning they return to ocean waters. Their coastal migratory range extends from the Bay of Fundy, Nova Scotia south to coastal waters of Virginia. The oldest American shad observed in the Hudson has been age 13. Hudson shad can spawn up to eight times during its life and can weigh up to nearly 4.5 kg, but average about 1.2 kg.

Current management is through a cooperative interstate fishery management plan coordinated through the Atlantic States Marine Fisheries Commission.

### The Fishery

Commercial harvest records suggest that the Hudson River American shad has suffered repeated over-fishing events since records began in the late 1800s. The highest peak of 1.9 million kg occurred in 1889. It is not known if fishing continued in the following five years; however, a second peak occurred in 1904 at 1.5 million

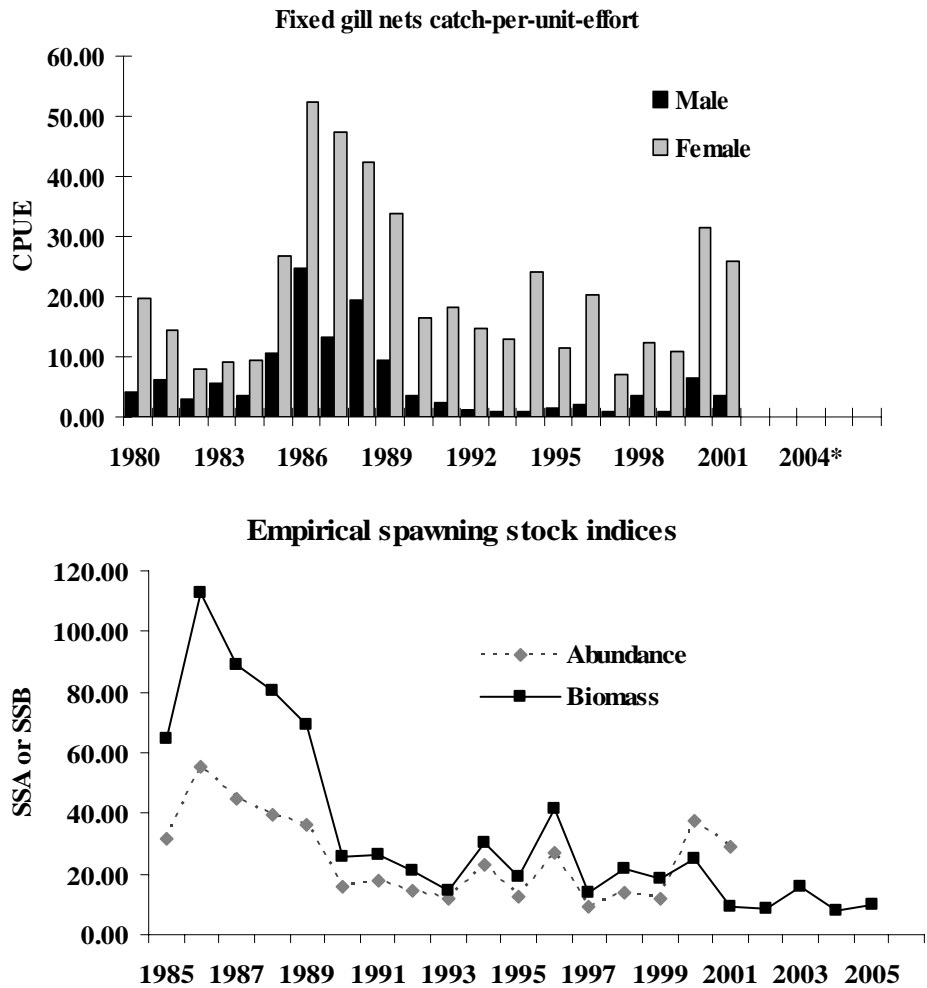


kg. From the turn of the 20<sup>th</sup> century until 1936, landings were relatively low. Over the period 1937-1948, just prior to, during, and after World War II, Hudson shad became a very important commodity on the world's food market. Sustained landings ranged from 1.1 to 1.9 million kg annually. From 1949 and through the 1950s, the stock rapidly collapsed. Fishing slowed for 20 years only to be followed by another resurgence in the 1980s. Landings have declined since. During this last resurgence, a mixed-stock fishery developed in ocean waters (landings not indicated on graph). Two major ocean fishery regulations were implemented after 2000. The first, the Harbor Porpoise Take Reduction Program (HPTRP) forced ocean shad gill netters to use smaller mesh sizes. This was followed by ASMFC interstate shad regulations which included a 40% decrease in effort in 2002, followed by a complete closure in 2005. Current ocean bycatch in other fisheries remains undocumented.

### Adult Abundance Indices

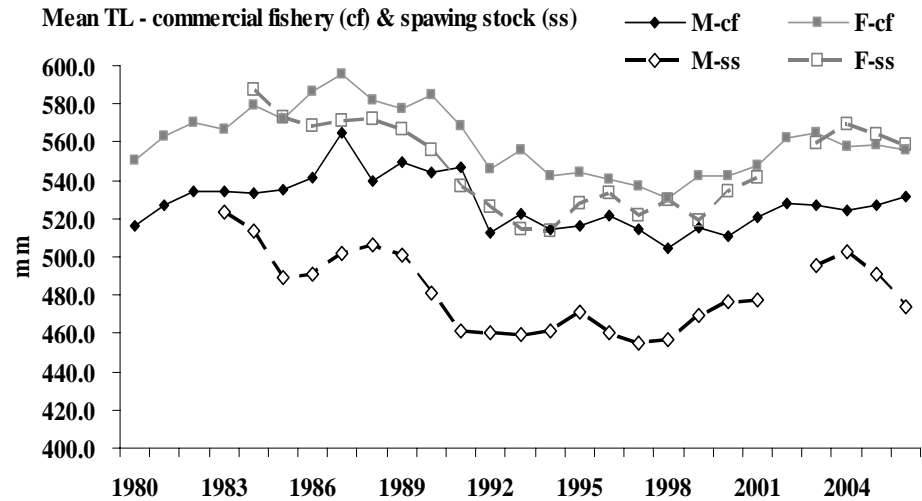
The in-river commercial fishery is monitored by onboard observers who obtain accurate catch-per-unit-effort (CPUE) data. We used data from the passive fixed gear gill-net fishery in the lower Hudson as annual indices of adult shad abundance because this location monitors adult shad as they migrate through the lower river to upriver spawning areas. Data are usable until 2001, when sample size became too low to provide confidence in estimates. CPUE declined from a high in 1986 to a low in the late 1990s. Female CPUE spiked in the last two years, coincident with the HPTRP implementation, which allowed larger fish to escape the ocean fishery.

We also calculated empirical indices of spawning stock abundance (ESSA) and biomass (ESSB). Indices were high in the mid-1980s, then decreased at a varying rate to the present lowest value of the 20 year time series.

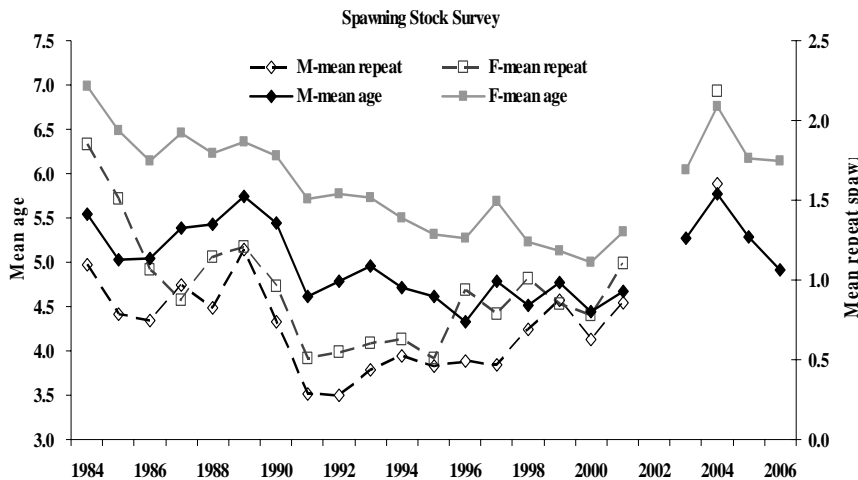


## Adult Size and Age

A decline in fish size occurred from the mid-1980s through the late 1990s concurrent with declining CPUE and landings. Samples from the fishery and the independent spawning stock survey indicated fish size was dropping. Larger, older fish disappeared through the late 1980s and mid 1990s. Some larger fish began to appear in 2000 after ocean restrictions banning large mesh gill nets occurred.



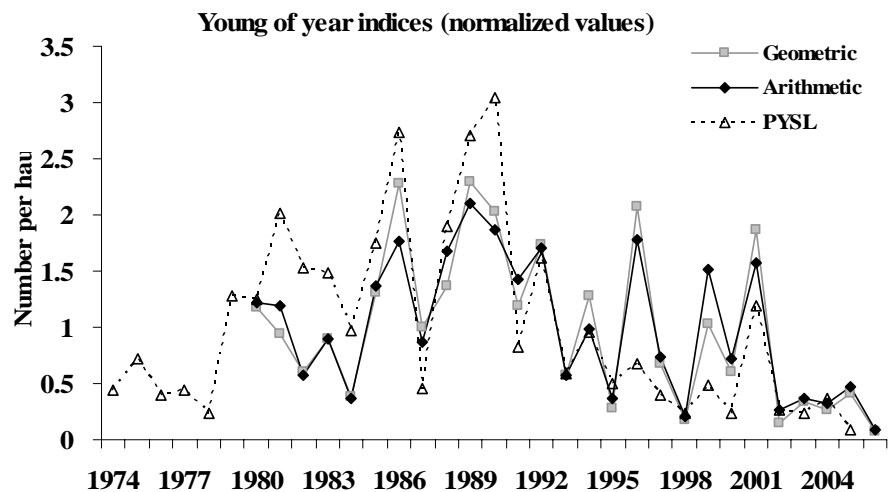
In 2004 and 2005, larger fish appeared, but smaller, younger fish disappeared, most likely a result of poor recruitment.



Mean age and mean repeat spawning showed the same trend. Mean age and repeats declined until 1994, then stabilized until 2000, with slight improvement for 2004 only.

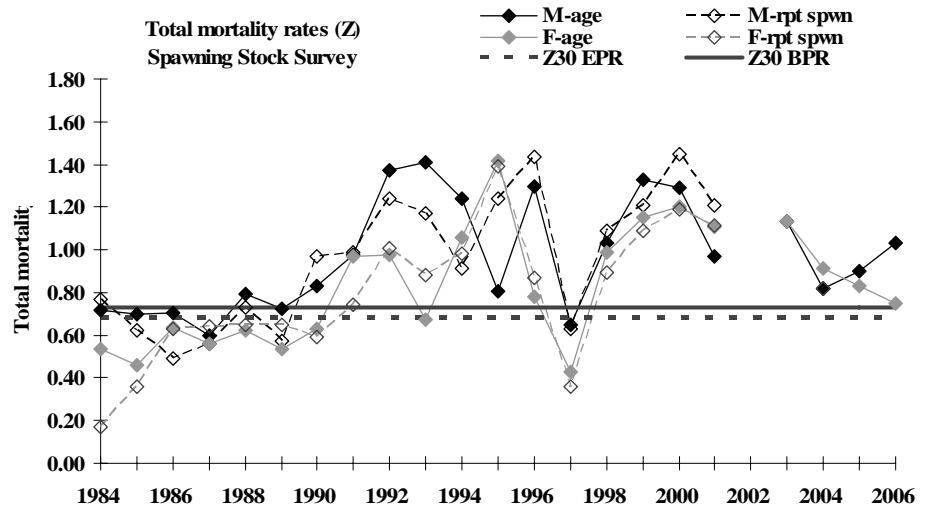
## Juvenile Abundance

The juvenile abundance indices, (beach seine and post-yolk sac larval), increased through the early 1980s when the spawning stock was high. It declined erratically to a very low value in 2002. It remains at this low level until the present.



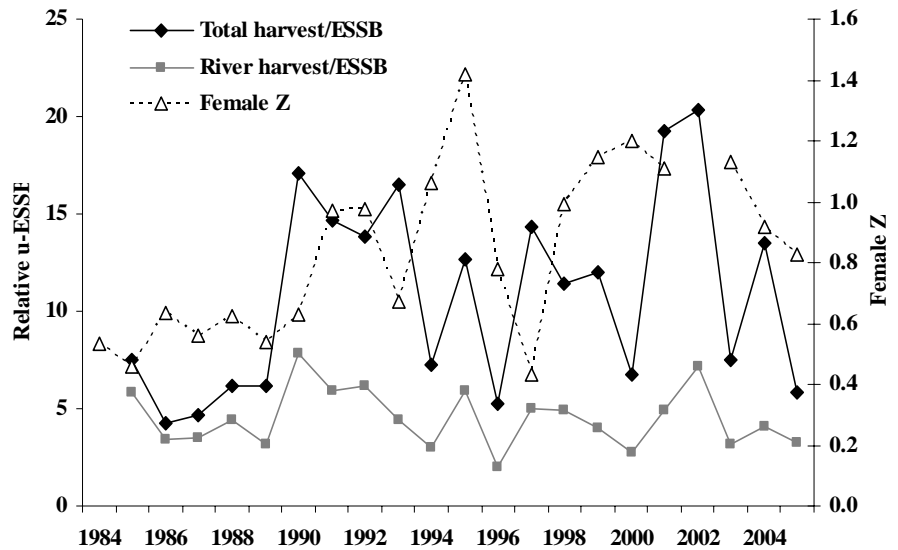
## Mortality Rates

We calculated acceptable rates of total mortality ( $Z_{30}$ ) for Hudson River American shad from a Thompson-Bell biomass-per-recruit model (BPR) using Hudson River inputs for weight-, maturity- and vulnerability-at-age, and natural mortality ( $M$ )=0.3, based on the maximum age of 13 observed in the stock. The resulting  $Z_{30}$ , also called a reference point was 0.73.



Total mortality estimates ( $Z$ ), calculated for the spawning stock show that  $Z$  for the Hudson River stock was stable in the late 1980s ranging from 0.4 to 0.8.  $Z$  began to climb through the 1990s and remained high, but variable, for the rest of the time series. Rates have been well over the acceptable rate of total mortality since the early 1990s.

We calculated relative exploitation rates from reported harvest (kg) divided by the spawning stock ESSB index. Relative rates using only in-river harvest varied without trend through the mid 1980s. However, relative rates that included total (river+ocean) harvest were relatively low through 1989, increased beginning in 1990, and have remained high since. The increase in relative exploitation in the early 1990s slightly before the increase in  $Z$  suggests that fishing that included the ocean harvest may have been the cause of recent excessive mortality in this stock.



## Habitat loss and degradation

Habitat loss and degradation from dredging and pollution only contributed further to the stock's decline. From the late 1890s through the 1950s, much spawning and nursery habitat (approximately 1,821 hectares or 4,500 acres north of Hudson NY) was lost in the upper half of the tidal Hudson because of dredge and fill operations to maintain the river's shipping channel.

New York City and Albany, as well as other major towns along the Hudson, added their share of pollution to the river. It was so prevalent that the Hudson was often referred to as an open sewer. Biological demand created by the sewage created oxygen blocks that occurred seasonally in some

sections of the river. One of the best-known blocks occurred during the 1960s and 70s near Albany in the northern section of shad spawning and nursery habitat, the other occurred through the 1980s in New York harbor. These oxygen blocks cleared up after implementation of the Clean Water Act and when secondary treatment plants came on-line.

The introduction of zebra mussels in the Hudson in 1991, and their subsequent explosive growth in the river, quickly caused pervasive changes in the phytoplankton (80% drop) and micro and macro-zooplankton (76% and 50% drop, respectively) communities (Caraco *et al.* 1997). These massive changes resulted in a decrease in observed growth rate and abundance of YOY fishes, including American shad. It is not yet clear how this constraint affects annual survival and subsequent recruitment.

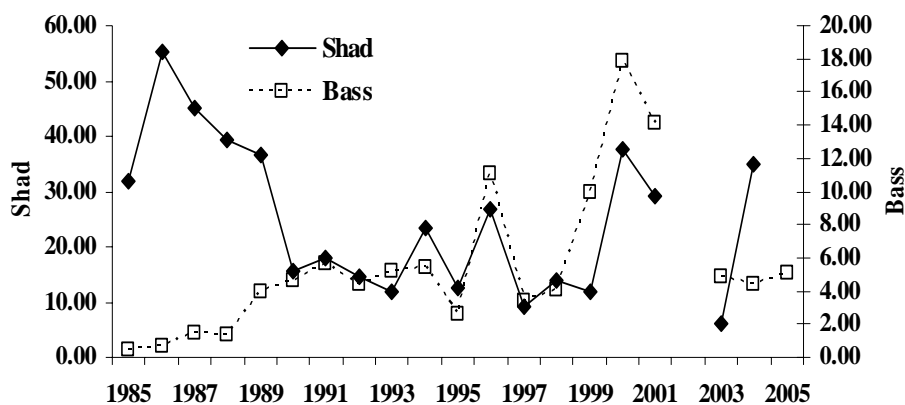
### Other theories on loss

Striped bass predation on young and adult shad has been suggested as a factor in the decline of American shad along the Atlantic coast. We examined effects of predation on adult Hudson River American shad through: 1. diet analyses of mature Hudson River striped bass; and 2. concurrent abundance changes in shad and bass in the river. We collected and examined the gut contents of 1,859 mature striped bass from the Hudson River from 1990 through 2006. Most fish were collected in spring during the shad and bass spawning periods. Most striped bass stomachs were empty (84%). Of those that contained food, unidentified fish and river herring were the most common diet items. Only two of 1,859 mature striped bass in this study had eaten adult American shad.

We also evaluated striped bass predation on juvenile American shad, and consider it to be a minor issue. Available diet studies of Atlantic striped bass suggest that *Alosa* species (shad and river herring) are a minor component of juvenile bass diets. Most large, mature striped bass do not consume small juvenile shad as larger food items are preferred (example: adult menhaden).

In addition we looked at relative abundance of both co-occurring species. Except for a brief period in the late 1980s, abundance of mature American shad and striped bass varied in the same direction suggesting no negative interaction between the two species in the river.

Relative abundance of Hudson River A. shad & S. bass



Total entrainment and impingement losses, due to once-through cooling water intakes at power generating stations were estimated to be as high as 50% in some years. Located in the upper end of the shad spawning habitat, the once-through cooling system at the old Albany Steam Station was the primary source of mortality. Since then, Albany Steam was purchased and retro-fitted with closed cycle cooling by the current owners. The other major power plant within the shad spawning area (Athens) also uses closed cycle cooling. The remaining power generating stations with once-through cooling occur from Newburgh Bay south. Losses at these plants are lower averaging about two percent per year (from 1974 through 1997).

