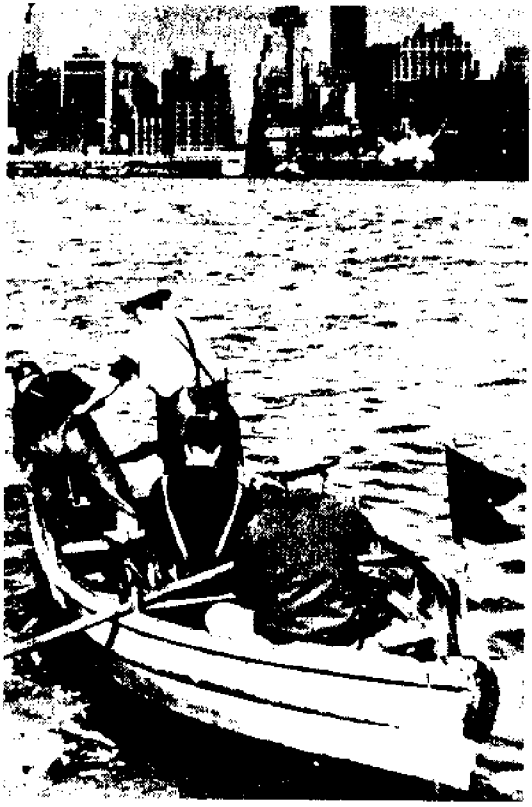
THE HUDSON RIVER SHAD FISHERY: BACKGROUND, MANAGEMENT PROBLEMS, AND RECOMMENDATIONS



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THE HUDSON RIVER SHAD FISHERY: BACKGROUND, MANAGEMENT PROBLEMS, AND RECOMMENDATIONS

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ABSTRACT

The Hudson River shad fishery has declined greatly in landings, value, and importance. To determine the causes of such a decline, this study evaluates past research on the Hudson River fishery and analyzes recent economic influences. The reduction in Hudson River shad landings in recent times was caused initially by overfishing during World War II. A reduction in demand for shad and a management-induced reduction in fishing effort has allowed the Hudson River shad stocks to return to abundance. Economic problems are now the major impediment to the rehabilitation of the Hudson River shad fishery. This study presents several recommendations for improved management and economic rehabilitation of the fishery.

INTRODUCTION

Historically the Hudson River was one of the greatest producers of American shad (Alosa sapidissima) along the east coast of the United States. The annual spring appearance of the highly regarded fish was once eagerly anticipated in the Hudson River Valley. However, recent landings of shad have been but a fraction of past landings.

Hudson River shad runs begin in April, much later than the first November runs in Florida. With modern transportation, fresh shad from southern rivers are already abundant on the New York market five to six months before the Hudson River shad season begins. Consequently the New York shad market is sated before the local product arrives, and Hudson River shad command a relatively low price.

New York and New Jersey share the southern Hudson River as a common boundary for 18 miles (29 km; see Appendix I for English/metric conversion factors). The rest of the river is entirely within the boundaries and jurisdiction of New York State. Although shad may swim as far upstream as Troy (154 mi, 248 km), the major spawning grounds are in the Kingston area, 90 miles (145 km) upstream.

At the turn of the 20th century, the annual Hudson River shad landings in New York and New Jersey averaged several million pounds (several thousand metric tons [MT]). Landings between 1904 and 1934 were low, averaging several hundred thousand pounds. In 1935 the total catch rose to 847,400 pounds (384 MT)--a 220-percent increase in weight over the 1934 figure. The combined Hudson River shad landings of New York and New Jersey continued to increase to a maximum of 3,809,400 pounds (1,728 MT) in 1944 but have steadily decreased ever since. Prior to 1935, the landings of New York fishermen were often several times as large as the landings of New Jersey fishermen. This pattern has reversed since 1936.

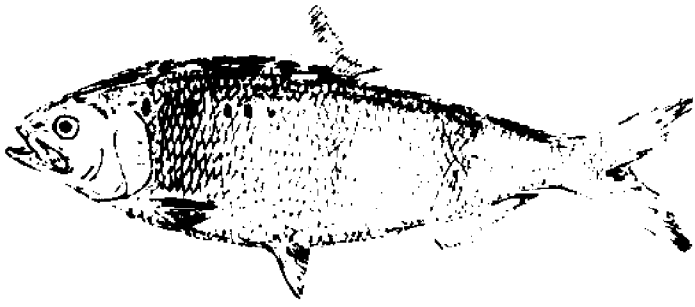
For several years, particularly during World War II, the Hudson River shad stocks were overfished and the catch declined precipitously; in 1950 only 1,008,900 pounds (458 MT) were landed. During the period of low abundance, several factors contributed to the present condition of the Hudson River shad fishery. Hudson River shad were reported to have a poor flavor caused either by oil pollution or flesh spoilage. A shift in the marine fishery strategy of New York State provided local markets with fishery resources other than shad. Furthermore, fish products were made available in more convenient forms than the very bony shad. These developments were accompanied by a shift in consumer preference away from shad.

LIFE HISTORY OF THE AMERICAN SHAD

The American shad (Fig. 1) is the largest member of the herring family found in United States waters. Males of the species weigh an average of 2 to 3 pounds (900 to 1,400 g), and have a fork length of 16 inches (400 mm). Females are generally larger than males at all stages; they weigh an average of 3 to 4 pounds (1,400 to 1,800 g) (Bigelow and Schroeder, 1953; Walburg and Nichols, 1967; Cheek, 1968). The shad characteristically has a laterally compressed fusiform body and a deeply forked tail. The dorsal surface is broader than the sharp, angular ventral surface, whose overlapping scales give a sawlike appearance. Dentition is limited to the lower jaw of the juvenile fish. In the migrating stage, the shad has a dark-green to bluish back and white to silvery sides and belly. Once the shad reaches the river, its back gradually fades to brown. The gill cover usually bears a dark spot followed by one or two longitudinal rows of dusky spots (Walburg and Nichols, 1967).

American shad are native only to the east coast of the United States, although shad were successfully introduced to the west coast in the late 19th century. Along the Atlantic coast, shad are found from the St. Lawrence River in Canada to the St. Johns

FIGURE 1 *The American Shad (Alosa sapidissima)*



River in Florida, and are most abundant in the waters between North Carolina and Long Island Sound (Svetovidov, 1963). Shad presently spawn in fewer rivers than they did during colonial times, and dam construction has greatly reduced the upstream limit of the shad run in most of today's shad rivers (Walburg and Nichols, 1967).

The shad spends most of its life in the sea and returns to spawn in the coastal river where it was born--a lifestyle termed anadromous (common to some members of the family Salmonidae). Unlike Pacific salmons, which spawn only once and then die in the rivers, Atlantic salmon and American shad may return in successive years to spawn in their native streams. Although most shad spawn for the first time at 4 or 5 years of age, exceptional males may mature and spawn at age 2 or 3, and a few females spawn for the first time at 3 or 4 years of age (Walburg and Nichols, 1967).

The annual spawning migration begins in Florida's St. Johns River in November and occurs successively later as temperatures increase in each of the more northerly shad rivers along the Atlantic coast. Hudson River runs begin in April and spawning is completed by July. In June, migratory runs begin in the St. Lawrence River. Males predominate in the early part of the run, whereas later, the sex

ratio is even or dominated by females (Svetovidov, 1963; Walburg and Nichols, 1967).

Spawning areas usually have sandy or gravelly bottoms, or a mixture of both. Depending on the river, these area are located from just above the estuary to several hundred miles up the river. In the Hudson (Fig. 2), the Federal Dam at Troy (mile point [mp] 154, 248 km), built in 1826, cut the northern limit of shad migration from Glens Falls (mp 209, 336 km) to Troy (Walburg and Nichols, 1967). In 1973, shad were reported upriver only as far as Albany (mp 145, 232 km).

Fecundity varies with the age, size, and home river of the female. Annually, the Hudson River shad lays between 116,000 and 468,000 eggs, which mature and are released over a period of several days. Successfully fertilized eggs sink to the bottom, where they are vulnerable to predation by eels and catfish, fungal infection, or suffocation by burial in mud or silt.

At water temperatures of 15°C to 18°C, shad eggs incubate in 4 to 6 days to produce larvae 0.3 to 0.4 inches long (7 to 10 mm). Transformation to the adult form occurs in 4 or 5 weeks--at a length of about 1 inch (25 mm) (Walburg and Nichols, 1967). The young shad spend their first summer in the rivers. As the water temperature decreases in the autumn, they migrate to the sea (Sykes and Talbot, 1958). Those shad that survive predation by such species as bluefin tuna, kingfish, and sharks return to their native stream to spawn in about four years.

After spawning, the spent adult fish, which have not fed since leaving the sea, begin feeding voraciously again (Svetovidov, 1963) prior to reaching the sea (Bigelow and Schroeder, 1953, reporting Atkins, 1887). Adults from rivers north of Chesapeake Bay migrate to the Gulf of Maine, where they spend the summer and autumn. It is presumed that shad spend the winter in deep waters of the middle and south Atlantic.

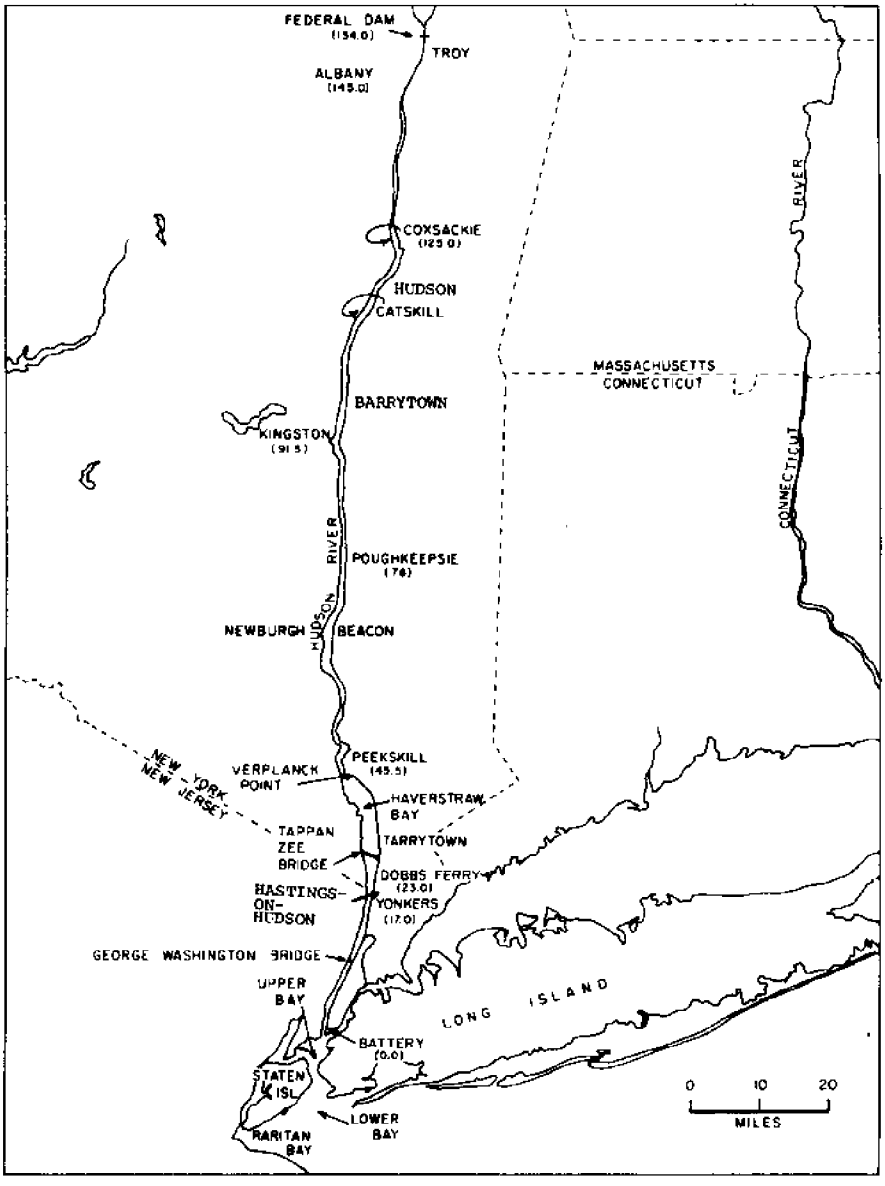


FIGURE 2 *Hudson River from New York Bay to the Federal Dam*

THE HUDSON RIVER

The Hudson River (Fig. 2) rises in the Adirondack Mountains of New York and flows southward for 315 miles (507 km) into Upper New York Bay. Between the mouth of the river at the Battery, New York City, and Dobbs Ferry, New York (mp 23, 37 km), the Hudson River has an average width of 1 mile (1.6 km). Haverstraw Bay, the section of the Hudson from Dobbs Ferry north to just below Peekskill, New York (mp 45.5, 73 km), varies in width from 3 to 4 miles (4.6 to 6.4 km). From Peekskill north to Troy (mp 154, 248 km), the average width of the Hudson varies from 200 to 2,500 yards (183 to 2,286 m). A navigational channel exists from the Battery to Albany (mp 145, 232 km). To facilitate commercial traffic, the depth of the channel is maintained where necessary at 30 to 48 feet (9 to 15 m). However, in reaches between Cornwall (mp 56.5, 91 km) and Peekskill, the channel depth exceeds 150 feet (46 m).

Since 1826 the Federal Dam at Troy has been the upstream limit of migration for Hudson River anadromous fishes (notably the American shad), the upstream limit of the estuarine section of the river, and the upstream limit of the influence of tidal fluctuation. Between this dam and the mouth of the river the Hudson has a drop of only 5 feet (1.5 m). Tides within the river are 4.4 feet (1.3 m) high at the Battery, 3.0 feet (0.9 m) at Beacon, and 4.8 feet (1.5 m) at Troy (Tofflemire and Hetling, 1971).

The upper Hudson River is a well-mixed estuary. Consequently, there is no distinct tongue of saline seawater. Because the intrusion of salt water depends on the strength of the river's freshwater discharge, the saltwater front (defined as at least 50 parts chloride per million) may extend upstream only to Yonkers (mp 17, 27.4 km) during periods of high spring runoff, or it may extend as far upstream as Poughkeepsie (mp 76, 122.3 km) during periods of low runoff in the late summer (Giese and Barr, 1967). Seasonal changes in precipitation also greatly affect the river's net flow, which

varies from 2,000 to 40,000 cubic feet/second (56 to 1,120 m^3/sec^{-1}) (Eisenbud, 1971). However, the 300,000 cubic feet/second (8,400 m^3/sec^{-1}) tidal flux of the Hudson River estuary is an order of magnitude greater than the maximum river flow.

Being a common property resource, the Hudson River serves the people of New York in a multitude of ways. One of the oldest continuous uses of the river is as a commercial waterway. Recreational boating and recreational and commercial fishing were also important activities on the Hudson. Eisenbud (1971) reported that prior to 1700, whales were seen almost daily in New York Harbor and that around 1830, a short-lived whaling industry existed in Newburgh and Poughkeepsie. Among the fish which have been taken for sport in the Hudson River are the striped bass, shad, alewife, blueback herring, largemouth bass, yellow perch, white perch, white catfish, chain pickerel, pumpkinseed, American eel, and sturgeon (US Bureau of Outdoor Recreation, 1966). In the middle 1960s, the annual income from sportfishing to the communities of the lower Hudson River was estimated at $20 million (Carlson and McCann, 1969). Until recently, the river's commercial fisheries were dominated by the shad fishery. Oyster grounds once occupied 350 square miles (907 km^2) along the lower Hudson and produced in excess of 1.5 million bushels (53 million liters) of oysters annually. The most important causes of the collapse of this oyster fishery were reported to be mismanagement, overfishing, siltation, and pollution (Gould, 1971).

Potable water has always been a commodity in high demand by the people of New York City. In the early 1880s, a Bradford Seymour proposed an intriguing but never-implemented plan: to dam the Hudson near the northern limits of New York City so that an 18 to 24-foot (5 to 7 m) head of fresh, potable water could be maintained (Eisenbud, 1971). This proposal was rejected not only because the locks might pass salt water, but also because the dam might destroy the important Hudson River shad fishery.

The Hudson has also acted as a sewer for the wastes of communities and industries within its watershed. And most recently, the river has supplied cooling water for the increasing number of power plants along its banks.

One consequence of common property resource management is that the activities of some users conflict with the requirements of other users. In the Hudson River, shad fishermen have repeatedly blamed declines in shad catches on the effects of other uses of the river:

> An [sic] explanatory of the decrease of certain fisheries on many rivers it has been alleged that the same has been due to such deleterious influences as the disturbance of the waters by passing steamers, the pollution by sewage, and the refuse of paper, calico, and other factories in operation along their banks (McDonald, 1887).

Industrial and residential development along the Hudson has led to pollution. Oil from leaking or illegally pumped fuel barges, tankers, and freighters has added to this (Hudson River Valley Commission, 1966). Organoleptic tests by the US Fish and Wildlife Service indicated that 18 of 20 shad tested had a definite off-flavor, tasting of gasoline or kerosene (Talbot, 1954).

Yet according to Lanahan (1973), in the last seven years New York has turned the corner on pollution in the Hudson. In 1965 Governor Nelson A. Rockefeller sponsored the $1 billion Pure Waters Bond Issue. Since its passage, the Pure Waters Program has made $921 million available for sewage treatment plants. Eventually, the new sewage treatment plants will be capable of treating 400 million gallons of waste water daily (Lanahan, 1973). Operation of these plants will reduce the biological oxygen demand, but this type of treatment will remove neither nutrients nor metals from the waste water.

A series of water monitors has been installed along the Hudson to "serve as a warning system in case of sudden low-oxygen or poor water conditions that could endanger drinking water supplies or

fish life" (Lanahan, 1973). Industrial polluters have been forced either to treat their wastes before dumping them into the river or to dispose of their wastes via an adequate municipal treatment facility. Stricter enforcement has also curbed oil pollution in the river. Finally, continued improvement of river quality and consequently, of Hudson River shad, received further impetus with the approval in 1972 of the $1.15 billion Environmental Quality Bond Act. The act will provide $650 million for construction of an additional 40 sewage plants along the Hudson (Lanahan, 1973; Baskous and Lanahan, 1973).

Other signs of improvement are the return of the blue crab (Callinectes sapidus) to the lower river, and the return of clams in commercial abundance to the river's New Jersey shore (Bird, 1973). The US Public Health Service conducted a study of the hard clam resource in Raritan Bay (reported by the Hudson River Valley Commission, 1966), which indicated that there was a standing population of hard clams in excess of 1 million bushels (35,238,000 liters) in Raritan Bay alone. With sufficient continued pollution abatement, this resource may be of harvestable quality in the future.

MANAGEMENT OF THE HUDSON RIVER SHAD FISHERY

Early fishery managers recognized the importance of allowing adequate "escapement" of adults to the spawning grounds, and they attempted to manage the Hudson River shad stocks accordingly. However, in the past, several variables other than numbers of spawners were assumed responsible for the decline in shad abundance. These variables, also believed to affect the survival of newly spawned shad, included pollution, reduced freshwater runoff, channel dredging and resultant siltation of spawning grounds, and increased shipping traffic.

Two investigators looked into the decline in shad stocks: Burdick (1954), using graphic techniques, and Talbot (1954), using multivariate statistical techniques, showed that escapement is far more

important than any other variable studied in determining future population sizes (although, in a strict, statistical sense, neither author demonstrated a cause-and-effect relationship).

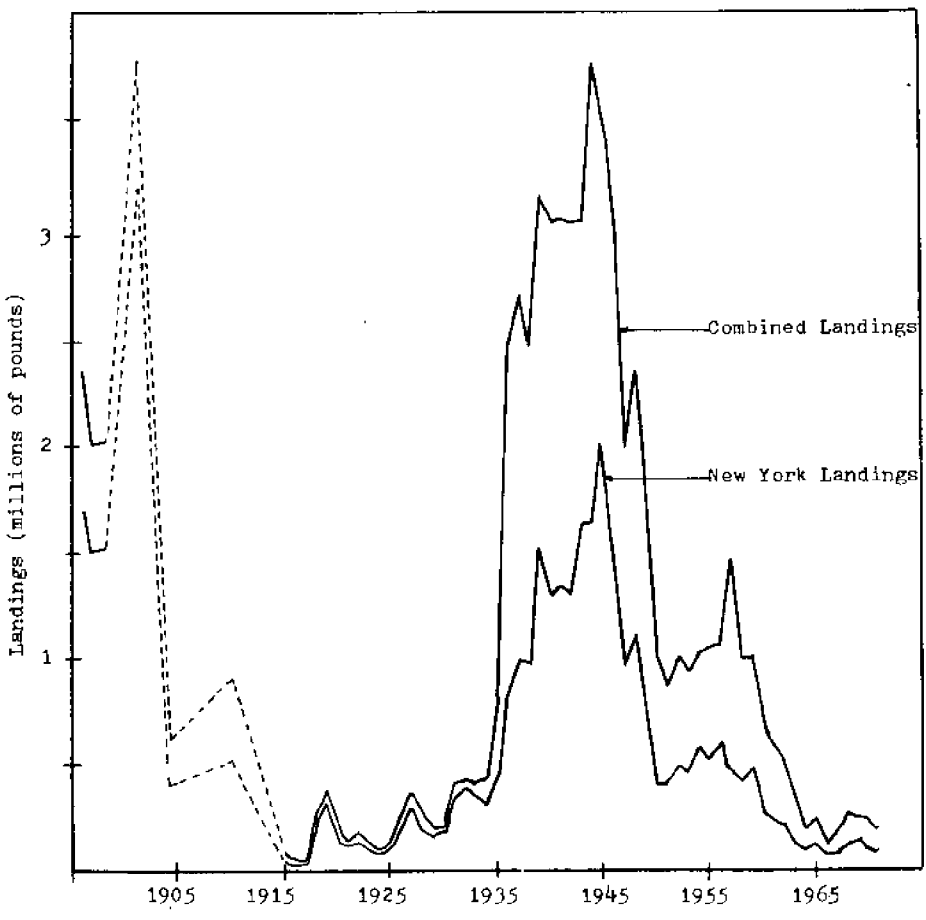
Since 1915 New York has utilized "lift periods" to help manage the Hudson River shad fishery. During a lift period, all nets must be lifted from the water to allow spawning stock to pass without being captured. The lift laws have varied over time with respect to the length of lift period and the area covered by the lift. In the first three years of the New York lift laws (1915-1917), the lift period was 2 1/2 days per week and extended from the Federal Dam at Troy downriver to Verplanck Point, just north of Haverstraw Bay. From 1918 to 1939 the lift law included all of the Hudson River under the jurisdiction of New York State, and the lift period was 2 1/2 days per week.

In 1940 New Jersey established a lift period, and both states abstained from fishing for 1 1/2 days per week between 1940 and 1942. Neither state observed a lift period during the war years 1943 and 1944. Between 1945 and 1950 New York and New Jersey again observed a 1 1/2-day lift, altered to a 3-day lift in 1951. Presently, for each week of the shad season (March 15 through June 15) fishermen must remove their nets from the water between 6:00 AM EST Friday and 6:00 AM EST Sunday--a 48-hour lift.

During the shad season, another fishing restriction prohibits nets from the spawning grounds north of Kingston Point. This area, "The Flats," is delineated by the shoals between a red buoy north of Kingston Point and a red buoy opposite the village of Barrytown (Section 36.1 [6], NY Fish and Wildlife Law, 1972).

In season, shad of any size may be legally captured. However, the market structure favors large female shad (roe shad). The eggs (shad roe) are a highly regarded delicacy. Males (buck shad) are smaller and generally less in demand than females.

FIGURE 3 *Landings of the Hudson River Shad Fishery*



The upper curve represents the combined New York/New Jersey landings. The lower curve represents New York landings. The dotted line is the estimated trend in landings during a period with few data points (see Appendix II-1).

Source: Fishery Statistics of the US, 1939-1971. See Appendix III for earlier titles.

Article II, title 3 of the NY Fish and Wildlife Law (1972) provides the fishery manager with tremendous power to regulate the shad fishery in an "emergency." An emergency exists when the catch of Hudson River shad by New York licensees falls below 75 percent of the 1939 catch, i.e., below 1,137,100 pounds (515.8 MT). During such a period, the NYS Department of Environmental Conservation (EnCon) may regulate the number, type, and length of gear used to fish. The format of this emergency clause renders it ineffective: because catch statistics are collected only at the end of the fishing season, the population can be overfished before the statistics necessary to determine emergency conditions have been collected.

EnCon may also close seasons, protect waters, or take other action which "in its judgment may be desirable to the protection of the shad fishing of the Hudson River" (Article II, Fish and Wildlife Law, 1972). But New York landings have been below the "emergency" level since 1946, and the emergency clause has never been used to regulate the fishery (Lawrence, personal communication; Parker, personal communication). This lack of action was presumably based on the belief that recent low landings are the result of reduced fishing effort. The absence of "instantaneous" catch data precludes accurate assessment of the fishery until the end of the season, when the final statistics are recorded. In effect, the law provides for regulation only after the damage has been done.

At the request of the Atlantic States Marine Fisheries Commission, in 1950 the US Fish and Wildlife Service undertook a long-term study of the American shad along the Atlantic coast of the United States. The investigation was spurred by the decline of Atlantic coast shad landings from 50 million pounds (22,680 MT) in 1896 to less than 8 million pounds (3,629 MT) in 1950.

The study began in the Hudson in 1950, and extended to other river systems along the Atlantic coast in 1951 (Talbot, 1954). At the conclusion of the study, the Biological Section of the Scientific Committee of the Atlantic States Marine Fisheries Commission

stated: "The Hudson River...fishery can now be managed successfully" (Atlantic States Marine Fisheries Commission, 1958). Despite this optimistic statement, landings continued to decline. In 1958 Hudson River shad landings totaled about 1 million pounds (454 MT). Only eight years later, landings declined to 67,908 pounds (31 MT) (Fig. 3, Appendix II-1).

McHugh (1972) analyzed commercial landings of fish and shellfish in New York State, dividing the history of landings since 1880 into three periods. During the first period, ending around 1930, the industry developed shallow-water coastal fisheries. The next two decades were characterized by an offshore extension of coastal fisheries. In the third period (1950-1970), landings declined steadily and the industry returned to inshore fisheries. As the abundance of each species decreased, the industry shifted its fishing effort to other species. This practice of "pulse fishing" has meant continuous change in the kinds of fish and shellfish available on New York markets, and the source locations of these products.

McHugh concluded from the steady decline of New York commercial shad landings between 1945 (2,850,000 lbs, 1,293 MT) and 1970 (95,900 lbs, 44 MT) that a "virtual collapse of the fishery" had occurred.

Initially, poor management reduced the availability of shad. However, there were many factors involved in the recent decline in shad landings. Along with a downturn in the number of licensed nets from 242 in 1945 to 62 in 1970 was an apparent decrease in the amount of fishing, or fishing intensity, by each fishing unit. Consequently, the collapse of New York's shad fishery was due more to reduced fishing effort than to mismanagement. Analysis of data showing catch per unit of fishing effort (C/E) for the Hudson River shad fishery supports this conclusion.

For maximum effectiveness, the previously mentioned emergency clause of the Fish and Wildlife Law should have been based on a model which related the abundance of fish to C/E data. A notable

model of this type was formulated for the yellowfin tuna fishery of the eastern Pacific Ocean (Schaefer, 1967, 1970).
Fredin (1954) developed a technique to calculate the size of the spawning escapement of a shad fishery. Talbot (1954) applied a statistical technique called a multiple regression analysis to predict the size of a shad run, using the size of the escapement of previous years. Schaefer's model and the escapement-regression method of Fredin and Talbot allow the fishery scientist to forecast the future condition of a shad stock, but an accurate forecast is dependent on accurate and current C/E data.

GEAR

Hudson River shad fishermen use several types of gear. In nearly all cases the net is stationary or "static." The effectiveness of static fishing techniques depends on fish moving into the gear. Active techniques require a vessel to work the gear about the fish (Sainsbury, 1971).

The gill net (Fig. 4) is, and has been, the principal gear used to catch Hudson River shad. It consists of a large wall of netting suspended vertically in the water column. The top of the net is secured to a float or cork line which buoys up the net. A lead line weights the bottom of the net. The balance between the positive buoyancy of the cork line and the negative buoyancy of the lead line determines the depth at which the net fishes.

A shad encountering a gill net will try to pass through the openings or meshes in the net, but when its body girth equals the perimeter of the mesh, the mesh catches behind the operculum (gill cover), the scales, or the fins.

Mesh size is measured both in terms of bar mesh measurement and stretched measurement. The distance between two successive knots of a mesh is the bar mesh size. Stretched measurement is the distance between two diagonal knots of a mesh tautly stretched.

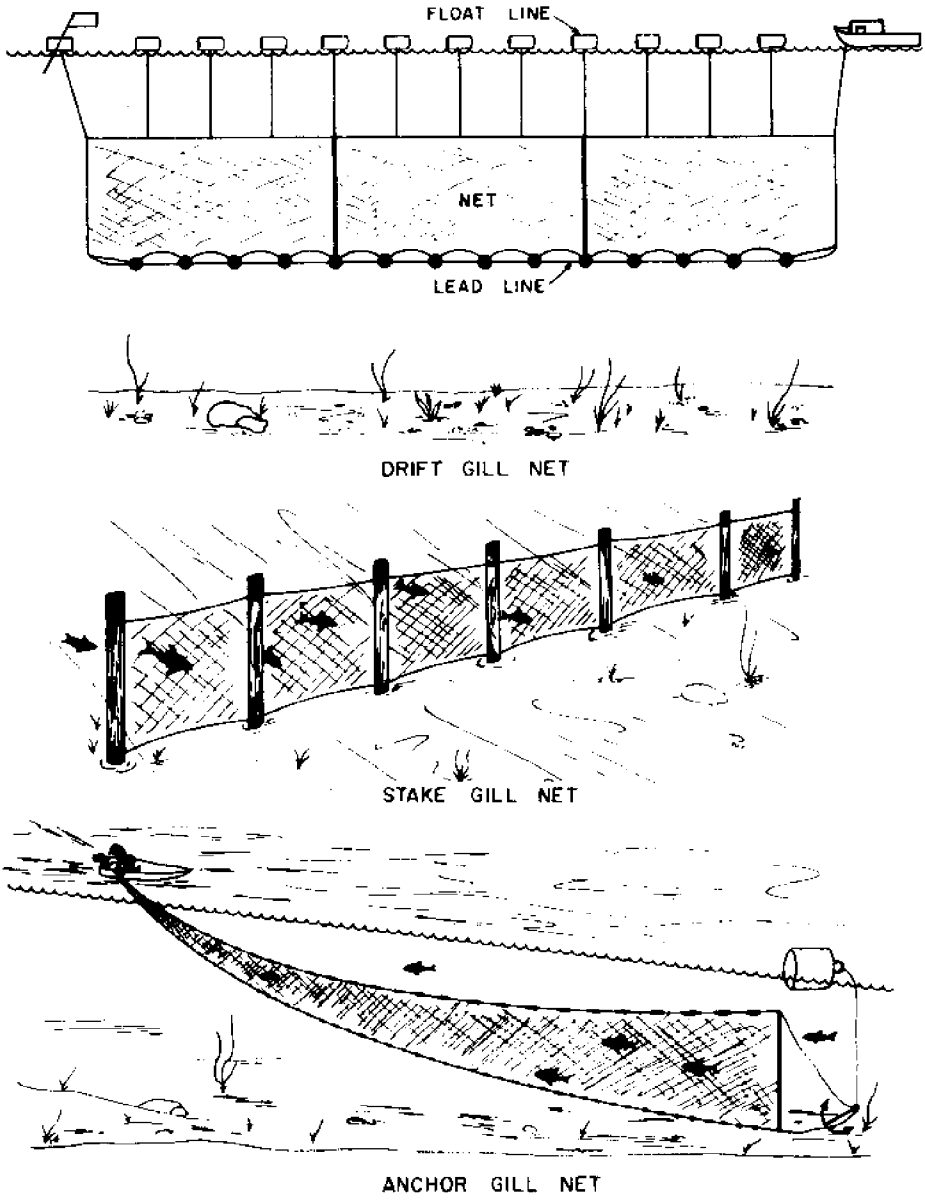
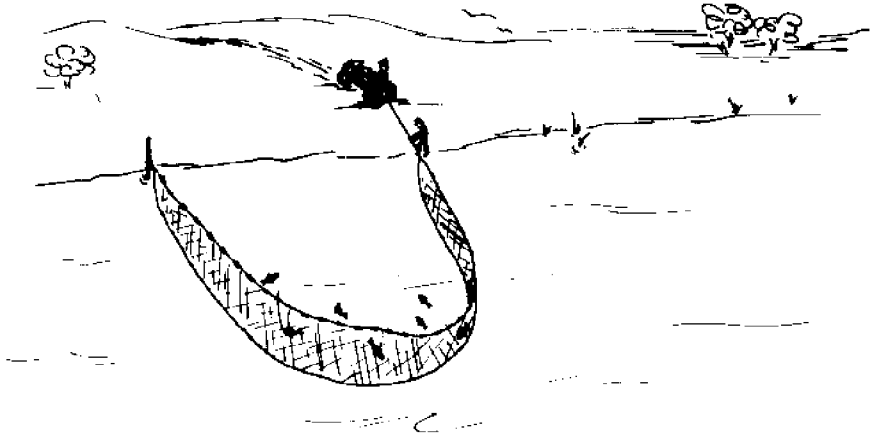


FIGURE 4 *Gill Nets* (after Tyler and McKenzie, 1973)



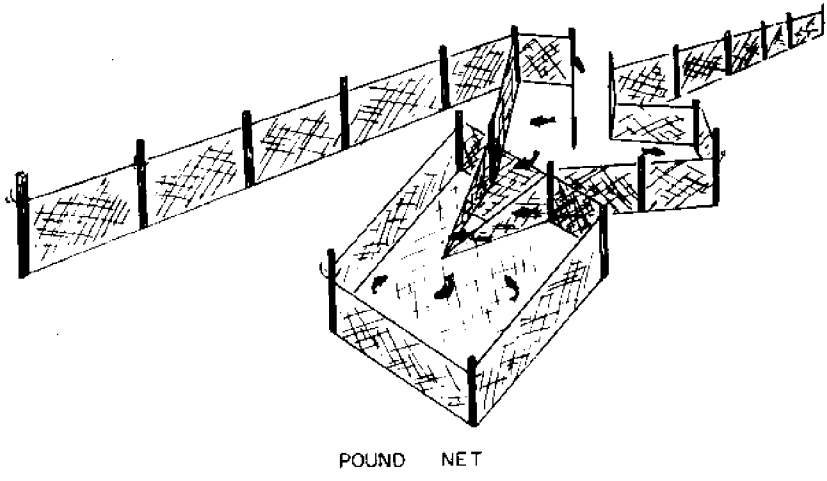
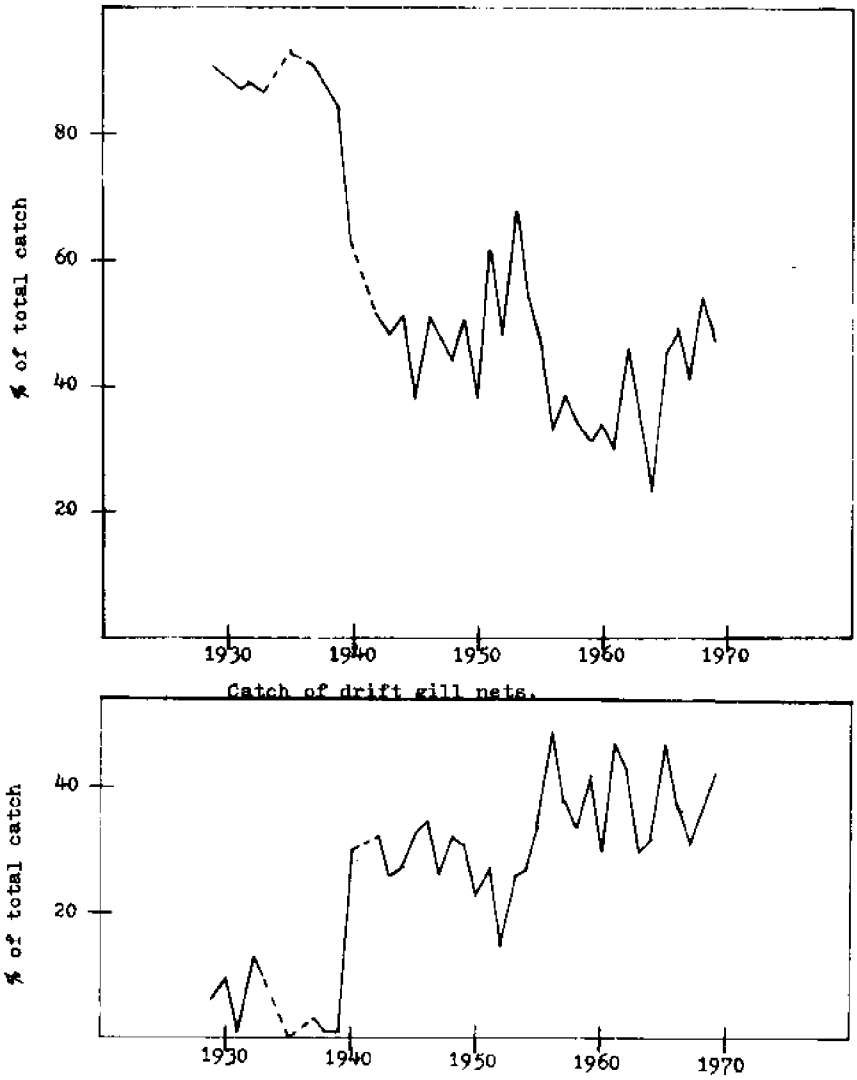


FIGURE 5 *Haul Seine and Pound Net* (after Tyler and McKenzie, 1973)

FIGURE 6 *New York Landings by Gear as Percentage of Total Catch*



Data compiled by William Knapp of the Marine Sciences Research Center, SUNY Stony Brook. See Appendix II-2.

Therefore, stretched mesh measurement is twice the distance of bar measurement. According to Talbot (1954), the stretched mesh measurement used in the Hudson River shad fishery varied between 5 inches and 5 3/4 inches, averaging 5 1/2 inches.

Hudson River shad fishermen have used four types of gill net. Stake gill nets and drift gill nets have always been of major importance (Figs. 4 and 6, Appendix II-2). A stake net is usually fished in heavy currents. Stakes driven into the bottom support the net at several points along its length. Like stake gill nets, drift gill nets are set perpendicular to the current. Unlike the truly static stake gill nets, drift nets float with the current. Both types of net are removed when the incoming tide diminishes the speed of the river current. Stake nets are removed from the river when the combined velocity of the ebbing tide and river exceeds the ability of the stakes to support the net. Drift nets are used further upstream in slower currents. Consequently, drift nets may be fished on the flood tide and the ebb tide.

Fishermen use stake gill nets in the section of the river downstream from Hastings-on-Hudson. They fish these nets only on the flood tide because the addition of ebb tide to the natural flow of the river causes extremely rapid currents. Most fishermen in the Haverstraw Bay region also use stake gill nets, which are fished on ebb and flood tides. Upstream from the city of Hudson, shad fishermen use mainly drift gill nets, fished on ebb and flood tides and removed from the river during slack water. Drift gill nets are also fished at night, when the water is clear.

Although no longer in use, anchor gill nets (Fig. 4) and runaround gill nets (not depicted) were once used occasionally. Anchor gill nets are suspended between an anchor at the river bottom and the float line on the net. Runaround gill nets are pulled behind two boats to encircle the fish.

Haul seines (Fig. 5) have been moderately important in the Hudson River shad fishery (Appendix II-2). Like the gill net, the haul

seine consists of a panel of mesh suspended between a cork line and a lead line. But seine meshes are smaller than gill net meshes and the twine is heavier. Containment rather than entanglement is the principle of seine fishing. One end of the haul seine is held stationary at the river bank while a boat deploys the net out into the river and back to shore in a U-shaped pattern. The net is then pulled in to shore and the encircled fish are captured.

Pound nets (Fig. 5) are not used in the Hudson River. However, they do capture many Hudson-bound shad along the shores of New Jersey and Staten Island (Nichols, 1958). A pound net has three components: leader, heart, and pound. All three are constructed of fine mesh netting supported by stakes. The leader is set perpendicular to the shore to intercept fish, which turn at the leader and follow it to the heart and pound. The heart (which gets its name from its shape) funnels the fish into the pound or trap. The pound is shoebox-shaped and has walls, a floor, and an entrance from the heart, but no roof. Fish are removed by raising the floor of the pound and dipping out the fish from above.

LICENSING

EnCon's Bureau of Fish has limited the shad season to March 15 to June 15 inclusive. During this period shad may be taken south of the Federal Dam at Troy by licensed commercial fishermen from 6:00 AM EST Sunday to 6:00 AM EST Friday. There is a 48-hour escapement period from 6:00 AM Friday to 6:00 AM Sunday. Shad fishing off Staten Island, although technically in the marine district, is regulated by the same licensing procedure and rules for shad fishing in the freshwater district.

There are two categories of commercial inland fishermen. Regular gill netters license their nets at an annual rate of $.05 per lineal foot and are entitled to fish year-round, subject to the rules and regulations of the Bureau of Fish. The shad catch of the regular gill net fishermen is not included in the total Hudson River shad

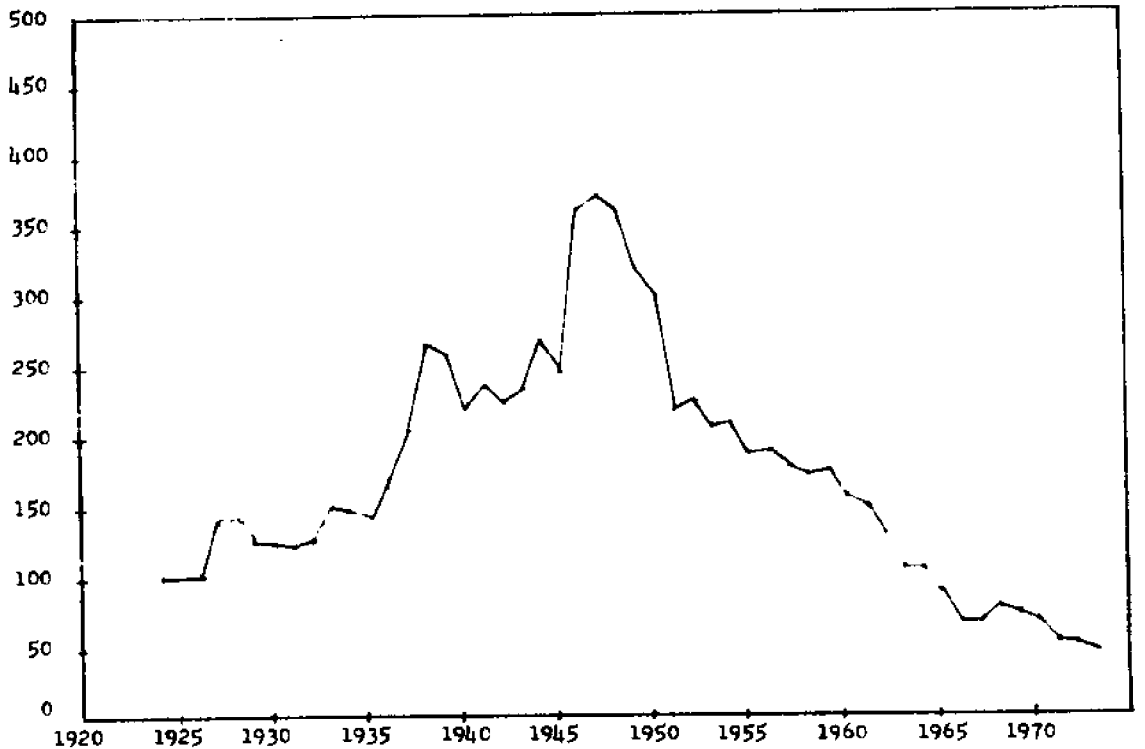


FIGURE 7 *Annual Number of Licenses for the New York Hudson River Shad Fishery*

Source: Hudson River Valley Commission, 1966.

catch in official statistics. Talbot (1954) reported that this catch was insignificant, but he supplied no catch statistics as verification.

Special gill net fishermen may fish only during the March 15 to June 15 shad season. They license their nets at $10.00 per net (maximum length 2,000 ft). Nonresidents and aliens may obtain licenses in each category at the rate of $.15 per lineal foot and $100.00 per 2,000 lineal feet, respectively (Section 35.1, NYS Fish and Wildlife Law, 1972).

Low returns--decreased demand for shad, the rigors involved in gill netting, and only small opportunities for commercial profit-making--have decimated the New York Hudson River shad fishermen. From a high of 349 in 1950, their number decreased to 40 in 1973 (Dietsch, personal communication; Fig. 7). Virtually all of these license-holders are casual fishermen. Most shad fishermen have special licenses and fish only part-time while holding other full-time jobs (Wich, personal communication; Francis and Busch, 1973; Talbot, 1954). Of these, some fish during leaves of absence from their full-time jobs and/or in the mornings and evenings before and after work. Some shad fishermen are retired from other occupations. Recreation and the chance to augment regular income are the two important incentives for the part-time fisherman.

ERRORS IN REPORTING FISHERY STATISTICS

Within 15 days of the close of the shad season, each fisherman must report his seasonal catch to the Division of Fish and Game. In some cases there have been incorrect data or errors in data reporting; both types of error bias the apparent condition of the shad stocks.

The individual fisherman is responsible for some errors: 1) he may not keep accurate records of his catch; 2) he may purposely falsify his reported catch, perhaps to avoid income taxes; or 3) he may have thrown large numbers of bucks (male shad) overboard

to prevent an abundant supply of low-valued fish from depressing the price of the more highly valued females (roe shad).

Truly central markets for shad do not exist, for the fish are sold to neighbors and local markets or their representatives as well as to the larger markets (like the Fulton Fish Market in New York City). The ultimate disposition of their catch is also diverse (e.g., fresh fish, smoked fish, roe). Because the markets are so diffuse, there has been no check on the accuracy of the recollections of the fishermen.

Another type of error in data reporting has been inaccurate transcription of data by the collecting agencies. For several years the Hudson River shad fishery statistics were inaccurately transcribed and/or the fishery was grossly mismanaged. Data from the US Fish and Wildlife Service indicate that the number of drift gill nets used in New York increased from 126 in 1934 to 281 in 1935 and then decreased to 124 in 1936. This is a very large two-year fluctuation. Similarly, the number of drift gill nets reported in use increased from 73 in 1916 to 213 in 1917. This increase was accompanied by only a modest increase in landings. One possible explanation for these inconsistencies is that perhaps fishing effort was increased to compensate for poor catches caused by a scarcity of fish.

Also suspect is the number of stake gill nets which the US Fish and Wildlife Service reported for the New York State Hudson River shad fishery between 1934 and 1945. In 1934, 14 stake gill nets were reported; none was reported in 1935. In alternate years between 1936 and 1944 the number of nets reported was suspiciously high compared to the figures for the odd-numbered years in between: 1936--551; 1937--26; 1938--301; 1939--139; 1940--380; 1941--129; 1942--353; 1943--78; 1944--317; 1945--122. Neither the catch of the stake gill nets nor the number or catch of drift gill nets fluctuated in a similar manner (Talbot, 1954). Erroneous

transcription of data is the most likely cause of these apparent fluctuations.

For almost the same period (1934-1949), several discrepancies appear in the records of the US Fish and Wildlife Service on the New Jersey stake gill net fishery. In 1935, 26 stake gill nets were reported operating in the New Jersey section of the Hudson (Fishery Industries of the US, 1938). However, Talbot (1954) found that the total number of stake gill nets registered in 1935 by the two New Jersey counties bordering on the Hudson totaled only 15 (Bergen County--15, Hudson County--0). Furthermore, the 18 miles (29 km) along which New Jersey nets are set (at a minimum legal distance apart of 1,500 yards [1,372 m]) can legally contain only 56 nets (Talbot, 1954). However, 672 nets were reported in 1936. During the periods 1936-1939 and 1945-1949, more nets were apparently operating in the New Jersey section of the Hudson than was legal. Paradoxically, this surplus did not appear in the records of the daily channel inspections made by the US Army Corps of Engineers.

Along with inaccurate transcription of data, there has been a problem of reporting vague data, although this has been less serious since New York and New Jersey started reporting the catch attributed to each gear type. In 1937 the annual report of the New Jersey Fish and Game Commissioners first included the number of stake nets owned by fishermen (Talbot, 1954); beginning in 1947 the number of licensed nets was reported--the number of nets actually fished would have been a more useful figure. Although New York has annual records dating back to 1924 of New York Hudson River shad catch and the number of licenses issued for stake, drift, and regular gill nets, only in 1940 did New York start listing the catch of the stake and drift gill nets separately.

Because the lower Hudson River is bounded by two states, compilation of statistics for this area has been a troublesome procedure. Each

net that extends across the midline of the river requires a license from both states. The current and past practice of assigning more than one license per unit gives deceptive data.

The minimum size and maximum length of the gill nets are controlled by law, but the maximum depth of the nets is not legislated. If a fisherman owns several nets, possibly of different dimensions, he is free to apply his license to any one of the nets. Maximum effort could be recorded when in fact it does not exist. Fishermen also spend varying lengths of time fishing and are differentially effective in catching fish (factors include presence of outboard motors, number of men per boat, skill of fishermen). Attempts to determine the amount of effort put into a fishery merely from license records have therefore been only approximate.

EFFICIENCY CALCULATIONS

To determine the relative efficiency of the drift gill net and the stake gill net, Talbot (1954) published a table listing for each year between 1915 and 1951 the number of nets fished, the number of days during which nets could legally be fished, and the number of net-days for New York and New Jersey. He observed that 90 percent of the fish were caught during the middle six weeks of the 1950 and 1951 seasons, and he used only this period in his calculations. He felt that fishing effort was more uniform during this midperiod than during the early or late parts of the run. However, his figures give only the number of nets licensed to fish--not necessarily identical to the number of nets used. The number of licensed nets is the maximum number of nets that could have engaged in the fishery. Consequently, multiplying the number of licensed nets by the number of days of fishing in the six-week midseason increases the error. When the annual catch is divided by this inflated number, the resulting catch/effort ratio (C/E) is too low; historical overfishing can be theoretically demonstrated where it may not have actually existed.

Talbot (1954) also calculated the relative efficiencies of New York and New Jersey fishermen. New Jersey fishermen use only stake gill nets, but in New York, both stake gill nets and drift gill nets are fished. Talbot established the ratio of the two types of New York nets from field observations in 1950 and 1951 and used it in calculating the relative efficiencies of the New York and New Jersey fisheries.

He then determined historical statistics for shad populations. Only in the period 1940-1951 did New York license records distinguish between stake gill nets and drift gill nets. Talbot assumed--probably unjustifiably--a constant ratio of New York gear types in his calculation of New Jersey and New York efficiency, and applied these efficiencies to historical catch statistics. Whenever the ratio of New York gear types changed, the relative efficiencies of New Jersey and New York also changed. Inspection of Figure 6 and Appendix II-2 confirms the variability in landings by New York gear.

The effect of escapement on future population sizes was established by Fredin (1954) and applied to the Hudson River by Talbot (1954), who estimated the total population, fishing rate, and escapement from the Hudson shad fishery. The Fredin method allows estimation of population size for a given year if the total population size and fishing effort for any year and the catch and effort for the year in question are known. Total population size was estimated in the 1950-1951 tagging studies. Effort statistics were also gathered during 1950-1951.

Because there are intrinsic differences in types of gear and in the availability of fish at various locations, the relative efficiency of the New Jersey stake gill nets differs from that of New York stake gill nets. Basic to the Fredin technique is the assignation of relative efficiencies to the gear participating in the fishery.

Talbot (1954) determined that the average efficiency of a New Jersey net was 4.96 times that of a New York net. Thereafter, he used the New York gill net as the standard unit of measure of fishing effort. Assuming that New Jersey nets had removed a constant percentage of fish annually from the spawning stock, he estimated the total population of Hudson River shad for each year between 1915 and 1950 from the formula $N = \frac{C}{1-q^n}$ where N = total population (lbs), C = catch (lbs), q = percent of escapement, and n = number of standard fishing unit days.

However, not all types of gear engaged in the fishing were represented in estimating the relative efficiencies of the gear. As the styles and types of gear fluctuated, the relative gear efficiencies of New York and New Jersey also fluctuated, and this affected estimates of population size accordingly.

To obtain more accurate effort estimates for the equation, Talbot (1954) considered the effort of only the mid six weeks of the shad season, when maximal effort is presumably applied to the fishery. If the number of fishing days and the amount of effort is estimated for the mid six-week period, then the catch should also be based on this period. Using too high a catch (or too low a number of standard fishing unit days) will inflate the estimated population size.

The major accomplishment of Talbot's work was to substantiate overfishing as the primary cause of the decline in shad landings prior to 1951; Burdick (1954) concurred with the seriousness of overfishing. Although Talbot's and Burdick's results weren't published until 1954, the detrimental effects of overfishing on the shad stocks had been sufficiently established in 1951 for New York and New Jersey to attempt to allow greater spawning escapement by increasing the number of closed fishing days.

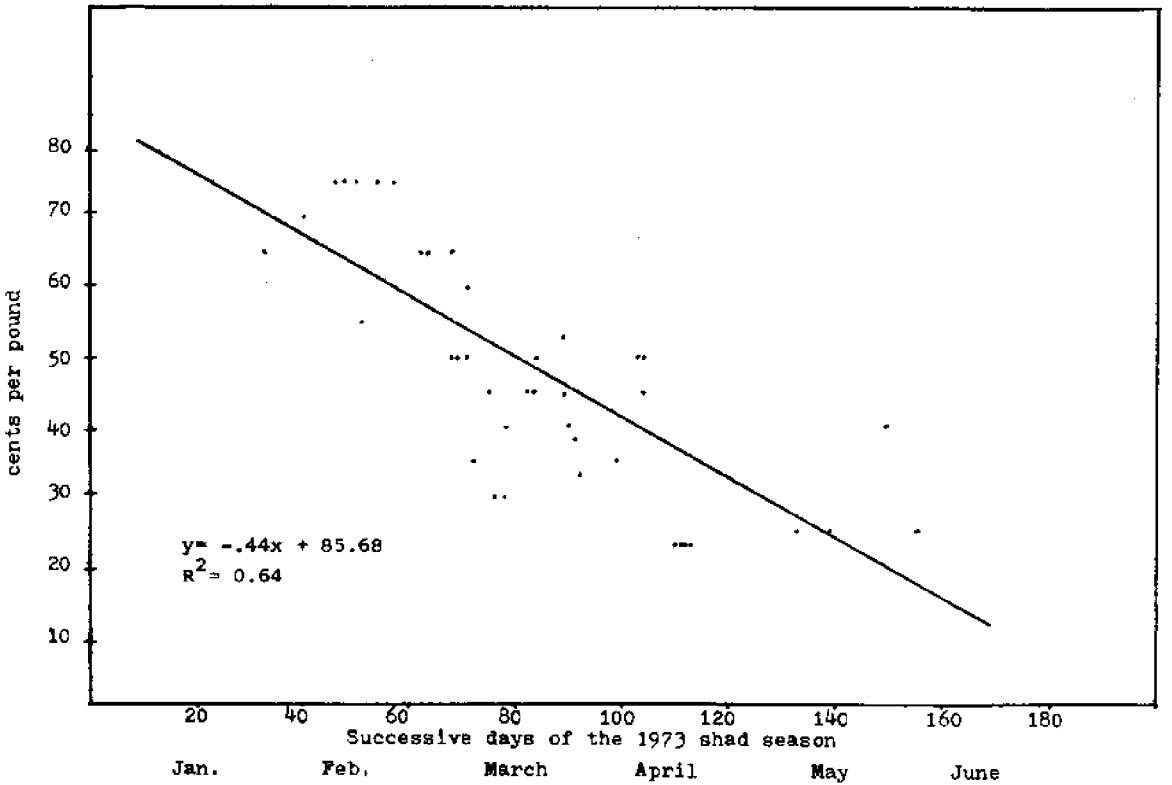


FIGURE 8 *Decline in 1973 Primary Wholesale Prices of Roe Shad at Fulton Market as the Season Progressed*

Source: National Marine Fisheries Service, 1973.

ECONOMICS OF THE HUDSON RIVER SHAD FISHERY

Several variables affect the economics of the Hudson River shad fishery. Among them are the seasonal nature of the fishery, the quality of the Hudson River shad, and competition in the market from other river systems, other species of fish, and other methods of preparation.

SHAD FROM OTHER STATES

In November, the beginning of the southern shad season, the supply is low and demand is high (Fig. 8, Appendix II-3). Consequently, shad commands a relatively high price. To avoid oversupplying local markets and to take advantage of the early demand, southern distributors ship their product to lucrative markets inland and northward. As the season advances and the availability of shad increases, the excess catch of each producing community is shipped to New York City, Philadelphia, Baltimore, and Washington, D.C.--the best shad markets (Johnson, 1938). Being the northernmost of these markets, New York City receives the excess shad of all producing communities (Table 1).

Historically, excess shad accumulated in the northeastern shad markets, and the product was frozen for sale at the end of the season, when the supply decreased and prices rose again (Fisheries Statistics of the US; Fishery Industries of the US). The relative scarcity of shad in the last few years has made this practice unnecessary. Nevertheless, the seasonal decline in shad prices with increasing abundance has been perpetuated in the New York market (Fig. 8). Almost all shad shipped to Philadelphia and Washington, D.C. are consumed within those metropolitan areas, but only 60 percent of the shad shipped to New York City is consumed within metropolitan New York. The rest is shipped to other markets (Johnson, 1938). The demand for shad on the New York market has been decreasing steadily. Hudson River shad enter the market after five months of increasing supply (Table 1) and decreasing prices

TABLE 1 *Availability and Receipts of Shad at Fulton Market, 1973*

State	*Commercial Abundance*	*Total Receipts (lbs)*
Atlantic Coast		
Florida	December-March	100
Georgia	January-April	130,600
South Carolina	January-April	9,400
North Carolina	February-May	22,500
Virginia	March-May	233,700
Maryland	March-May	--
Delaware	April-June	--
New Jersey	April-June	87,300
New York	April-June	64,700
Connecticut	May-June	63,600
Rhode Island	May-July	--
Massachusetts	May-July	--
Pacific Coast		
California	March-May	--
Oregon	May-June	--
Washington	May-June	--

Source: National Marine Fisheries Service, 1973.

dictated by the marketing practices of the southern shad-producing communities. The New York City market has been too saturated with shad from other states to value the late arrival of the local product.

SHAD FROM THE WEST COAST

Not only is the shad market already depressed by the earlier onslaught of southern distributors, but in April to June, when New York shad are available, shad are also commercially abundant in several other states (Table 1). The Pacific coast of the United States supports a modest shad fishery. Historically, Pacific coast distributors have shipped shad to eastern markets, primarily to New York City (Johnson, 1938). Quantities of Canadian shad were also imported to New York City (Johnson, 1938), although there have been no such imports in recent years (Fisheries Statistics of the US).

COMPETITION FROM OTHER SEAFOOD

The Hudson River shad fishery also faces competition in the market with other seafoods. Although shad is delicious, it is very bony, difficult to prepare, and spoils easily if not properly refrigerated or cooked. Its popularity has declined with the increasing abundance of shellfish, frozen "convenience" seafoods, and other fish.

McHugh (1972) analyzed New York State landings between 1886 and 1970, and found that in 1929-1935 and 1938-1951, the annual commercial landings of foodfish and shellfish in New York had increased greatly. Shad landings also went up during these years. From the 1930s to 1951, shad rose in rank of all seafoods from 21st to 12th. Other species with increased landings at this time were scup, striped bass, Atlantic herring, and silver hake. Lobster and scallops declined in landings and in rank.

Since the last peak in New York State shad landings in 1945 (2,850,000 lbs, 1,293 MT), annual landings of shad have steadily declined. During the period 1952-1970 the total landings of seafood in New York also decreased (McHugh, 1972), and the relative importance of several seafood resources changed. Shad landings dropped to 17th in rank. However, the other previously mentioned species showed considerable gains in rank. Sea scallops went from 10th place to 5th, American lobster, from 23rd to 12th, clams, from 9th to 6th. Among finfish, scup went from 5th to 1st place, silver hake, from 8th to 4th, striped bass, from 19th to 11th, and Atlantic herring, from 24th to 15th.

Shad first lost its importance in the market because abundance was low--caused by overfishing in the 1940s. Shad maintained its poor market position because of several economic conditions, among them, competition in the marketplace from other seafoods, notably the scallop, lobster, hard clam, surf clam, and striped bass. A lower demand for shad resulted, and this in turn brought about a reduction in shad fishing.

MARKET FORM OF SHAD

Marketability of fish often depends upon the marketed form. At the beginning of the season, shad bring their highest prices, so distributors ship whole eviscerated shad (in the round). However, as the profit margin decreases, only fillets and shad roe (the most valuable part of the female fish) are shipped to market to decrease transportation costs. Historically, shad were frozen when overabundant and then marketed when prices became more favorable to the wholesaler. But freezing is deleterious to the taste of the delicate shad flesh and, except for those shad used as bait, this practice has largely been discontinued.

Canned shad, canned shad roe, and smoked or kippered shad are also marketed (Appendix II-4). Because Pacific coast residents are not avid consumers of fresh shad, there is a canning industry there. In 1968, 1,190 standard cases of shad (53,000 lbs, 24 MT) were processed in three West Coast canneries (Appendix II-5). In 1969 the quantity of canned shad doubled: 1,998 cases (89,960 lbs, 41 MT) (Appendix II-6). Establishment of a fourth shad cannery in Virginia partially accounted for the increase (Fisheries Statistics of the US, 1969). But these figures show a marked decline from the 1936 figures in weight canned (833,000 lbs, 378 MT).

The canning of shad products traditionally has been limited to the Pacific coast (Appendices II-5, II-6). Although the number of plants canning shad roe decreased from five to three between 1969 and 1971, the quantity of canned roe increased by 400 cases and its value, with one exception, was the highest since 1962 (Appendix II-7).

New York State cans salmon, whitefish, lumpfish, and sturgeon roe; in 1971 four plants canned 12,236 standard cases, worth $4,013,717. But New York does not can shad roe (Fisheries Statistics of the US, 1971), although production capabilities do exist. Smoked shad,

something of a specialty item, has consistently been produced in small quantities and is the least valuable of New York's shad products.

Fresh shad is available in several forms. Shad in the round comes in large portions, averaging about 3 1/2 pounds (1,400 g). The fillets of one shad may weigh 2 to 2 1/2 pounds (900 to 1,235 g). Shad are tasty but bony, and "boning"--removing all the bones from a fillet--is a difficult, costly, and tedious task. In the shad industry, because there are few new recruits to replace experienced "boners," boned shad fillets are increasingly difficult and expensive to obtain. Furthermore, a pair of the final shad fillets recovered from dressing, filleting, and boning is only about 39 percent of the original weight of the fish (Johnson, 1938).

FISH-EATING HABITS

In 1936 the US Bureau of Fisheries conducted a survey among housewife consumers, restaurants, and retail stores to determine the basis for the decline in popularity of shad (Johnson, 1938). The study was conducted primarily in the South (Washington, D.C.; Richmond, Va., Newport News, Va.; and Columbia, South Carolina), but the responses to "Factors Adversely Affecting Consumption of Shad" are interesting and pertinent to the Hudson River shad fishery. All families surveyed were fish-eating families. Nearly two-thirds of all small families (of two or three people) considered the whole shad too large for economical use. This was only a minor complaint with larger families. Table 2 demonstrates the continual decline since 1900 of the size of the average American household. Table 3 indicates a decline in the average household size for 86 percent of New York counties bordering the Hudson River. Reduced New York family size may be partially responsible for recent declines in the demand for Hudson River shad.

Only one-third of the families polled preferred the taste of other species. Forty-five percent of these people were from Newport News

TABLE 2 *Size of the Average American Household, 1900-1971*

Year	*Number of Persons per Household*
1900	4.76
1910	4.54
1920	4.34
1930	4.11
1940	3.77
1950	3.52
1960	3.88
1970	3.23
1971	3.19

Source: US Bureau of the Census, Statistical Abstracts of the US: 1972 (93rd ed.).

TABLE 3 *Trend in Household Size in Counties Bordering the Hudson River*

	Population per Household	
	1960	*1970*
New York State	3.11	3.01
County		
Albany	3.10	2.93
Bronx	3.02	2.91
Columbia	3.17	3.06
Dutchess	3.23	3.21
Greene	3.11	3.00
Kings	3.05	2.94
Orange	3.18	3.17
Putnam	3.33	3.49
Queens	3.07	2.85
Rensselaer	3.19	3.10
Richmond	3.40	3.30
Rockland	3.46	3.59
Ulster	3.16	3.09
Westchester	3.24	3.08

Source: NYS Statistical Yearbook, 1973. NYS Division of the Budget/Office of Statistical Coordination.

and had been exposed to a constant supply of other fresh fish from a recently developed winter trawl fishery. Whereas shad was once eagerly greeted as the first seafood of spring, it had become just another seasonal seafood. Less than one-third of seafood-eating families reported that shad was too expensive.

Several families volunteered information on their questionnaires. About one-eighth complained of excessive boniness in the shad; about one-thirtieth reported that shad was too fatty or rich for their tastes.

POLLUTION

High-quality flesh is a prerequisite to public acceptance of a fishery product. Shad are esteemed for their predominantly light flesh and delicate oils. However, improperly stored, shad deteriorate rapidly and acquire the reported "petroleum" taste. The effect has been to divert former and potential shad customers to other products. Shad may increase in popularity now that the water quality of the Hudson River is improving and the reputation for bad taste is in the past. One commercial shad fisherman states that although he has been fishing the Kingston section of the Hudson for the past 12 years, he has never tasted a "polluted" shad. Certainly this is encouraging.

RECOMMENDATIONS

The marketing of shad has been a significant problem. The primary difficulty has been low demand. I recommend that the Hudson River American shad be publicized as a natural resource which, although seriously abused by man in the past, has been rehabilitated by New York State through wise management. The present high quality of the fish nullifies previous reports of low-quality, poor-tasting shad.

Shad bakes, excellent publicizers of the palatability of shad, could be associated with public events, such as organized picnics, outdoor social functions, and fishing clinics. There are professional

caterers who know how to prepare shad in great abundance. Their names should be compiled and made available to interested groups such as recreational fishermen's clubs.

New markets should be developed for shad. I suggest that areas to the north and west of New York City are most promising.

The roe of several fish (salmon, sturgeon, lumpfish) are canned in New York State. Currently, shad roe is canned only on the West Coast of the United States. I recommend a feasibility study of canning Hudson River shad roe in New York.

I further recommend a feasibility study of a Hudson River shad sportfishery. Because the Hudson is broad and the shad travel in channels not easily accessible to shore fishermen, docks, bridges, and boats should be investigated for use as fishing platforms. As the Hudson River becomes less polluted, the shad will advance further upstream, and the area directly south of the Federal Dam at Troy will become a more suitable location for sportfishing. The potential success of a sportfishery on the spawning flats, where shad are concentrated in numbers, should also be investigated.

Because New Jersey nets are further downstream than New York nets, migrating shad entering the Hudson encounter New Jersey nets first. This gives New Jersey fishermen the opportunity to catch more Hudson River fish than do New York fishermen. I recommend an arrangement for dividing the catch with New Jersey. This arrangement need not be in effect during periods of low landings that are the result of light fishing effort (the current situation). However, the appropriate time to establish management procedures is before they are needed. Once fishing effort and landings increase, New York fishermen and other citizens must be assured of a return for the money and effort expended in cleaning up and managing the Hudson River.

For the Hudson River shad fishery to be revived, a management program based on scientific principles will be needed. Accurate statistics of catch and fishing effort are essential to effective management. I recommend that the catch per unit of fishing effort (C/E) be adopted as a criterion for the assessment of the condition of the Hudson River shad fishery. For maximum effectiveness, the management program should include a model to forecast the future condition of shad stocks.

Each commercial shad fisherman in the New York section of the Hudson should be supplied with a notebook for convenient recording of catch and effort data. William Walters of the New York Sea Grant Institute's Advisory Service at Stony Brook has agreed to supply such a notebook, the format to be designed by an expert in the field of fisheries management. It should be stressed that the purpose of the book will be to help fishermen record data accurately; this in turn will facilitate management of the shad fishery. It is imperative not to give the false impression that the notebooks would be collected to check the income of fishermen.

NY Sea Grant Advisory Service maintains a computerized mailing list of New York commercial fishermen. The list is categorized by type of gear used, species fished, and so on. The mailing list is used by Sea Grant to publicize fishery developments of interest to commercial fishermen. I recommend that the commercial shad fishermen of New York be added to this list.

The NYS Fish and Game Law provides for emergency managerial action whenever annual shad landings fall below a certain level. Hudson River shad landings have been below that level since 1946. Landings statistics alone fail to show that light fishing effort--not scarcity of fish--is responsible for the recent low catches of Hudson River shad. I recommend that catch per unit of fishing effort (C/E) be substituted as the statistic upon which to base emergency management of the Hudson River shad fishery.

The fishery manager should be aware of the availability of shad throughout the fishing season. An effective rapid communication system must be established between the fishery manager and the fisherman. I recommend that each shad fisherman be supplied with a series of dated postcards--one for each week of the shad season. At the end of every week the fisherman would report his catch of shad and the amount of fishing effort invested in that catch. As a result, when necessary, the fishery manager could make rapid management adjustments. The previously recommended notebooks would help the fisherman record and report accurate catch and effort data. Such unsigned postcards would preserve the anonymity of the fisherman. The recommended computerized mailing lists would greatly facilitate notifying the fisherman of management changes.

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Appendix I Conversion Factors

To convert from:	To:	Multiply Column 1 by:
Length		
Inches	Millimeters	25.4
Feet	Meters	0.305
Yards	Meters	0.914
Miles (statute)	Kilometers	1.61
Millimeters	Inches	0.039
Meters	Feet	3.28
Meters	Yards	1.09
Kilometers	Miles (statute)	0.621
Weight		
Ounces (avdp.)	Grams	28.3
Pounds (avdp.)	Grams	454.0
Pounds (avdp.)	Kilograms	0.454
Pounds (avdp.)	Tons (metric)	0.000454
Tons (short)	Tons (metric)	0.907
Grams	Ounces (avdp.)	0.0353
Grams	Pounds (avdp.)	0.0022
Kilograms	Pounds (avdp.)	2.20
Tons (metric)	Pounds (avdp.)	220.0
Tons (metric)	Tons (short)	1.10
Capacity		
Bushels	Liters	35.2
Cubic feet	Cubic meters	0.028

Appendix II-1 Hudson River Shad Fishery Landings, 1896-1971

Year	New York		New Jersey		Total	
	Pounds	Value	Pounds	Value	Pounds	Value
1896	1,681,371	$58,921	675,595	$24,316	2,356,966	$83,237
1897	1,506,142	49,353	529,920	17,934	2,036,062	67,287
1898	1,534,877	50,875	606,423	18,510	2,141,300	69,385
1901	3,202,302	100,762	577,260	21,647	3,779,562	122,409
1904	402,496	28,896	201,800	17,758	604,296	46,654
1910	506,136	51,715	406,880	49,109	913,016	100,824
1915	48,564	5,969	20,104	2,674	68,668	8,643
1916	32,923	4,540	7,250	925	40,173	5,465
1917	38,344	5,810	5,040	720	43,384	6,530
1918	220,602	44,784	14,000	3,400	234,602	48,184
1919	301,306	60,690	73,668	23,034	374,974	83,724
1920	157,715	43,882	42,129	12,427	199,844	56,309
1921	104,883	24,329	25,920	6,294	130,803	30,623
1922	128,324	27,451	46,862	12,255	175,186	39,706
1923	97,863	22,644	23,865	6,000	121,728	28,644
1924	72,519	17,619	21,850	5,485	94,369	23,104
1925	110,359	24,030	13,975	2,400	124,334	26,430
1926	219,183	47,175	46,237	6,300	265,420	53,475
1927	299,693	56,950	58,362	6,700	358,055	63,650
1928	194,181	32,689	52,050	10,460	246,231	43,149
1929	157,895	25,801	38,850	4,882	196,745	30,683
1930	165,004	27,688	41,500	5,684	206,504	33,372
1931	342,611	40,840	72,000	8,941	414,611	49,781
1932	397,754	40,087	132,000	10,762	529,754	50,849
1933	347,656	28,156	171,024	12,573	518,680	40,729
1934	314,200	24,764	123,800	11,310	438,000	36,074
1935	453,300	38,151	394,100	32,485	847,400	70,636
1936	834,400	52,808	1,633,500	117,379	2,467,900	170,187
1937	976,000	73,191	1,756,200	139,595	2,732,200	212,786
1938	972,500	53,989	1,494,500	118,486	2,467,000	172,475
1939	1,516,400	66,319	1,754,300	98,943	3,270,700	165,262
1940	1,297,700	66,703	1,816,700	116,074	3,114,400	182,777
1941	1,341,000	91,041	1,792,500	107,589	3,133,500	198,630
1942	1,294,800	76,025	1,891,100	128,963	3,185,900	204,988
1943	1,640,000	155,800	1,585,350	201,556	3,225,350	357,356
1944	1,651,200	90,445	2,158,200	134,535	3,809,400	224,980
1945	2,091,300	275,962	1,385,900	228,161	3,477,200	504,123
1946	1,446,900	218,546	1,525,243	240,638	2,972,143	459,184
1947	957,400	95,527	1,024,392	161,447	1,981,792	256,974
1948	1,121,600	146,679	1,232,800	185,867	2,354,400	332,546
1949	748,800	113,[illegible]05	978,570	173,120	1,727,370	286,515
1950	413,600	62,012	595,300	118,137	1,008,900	180,149
1951	413,400	62,675	350,700	85,690	764,100	148,365
1952	487,600	59,150	589,500	87,552	1,077,100	146,702
1953	465,000	62,744	473,722	92,744	938,722	155,488

Year	New York		New Jersey		Total	
	Pounds	Value	Pounds	Value	Pounds	Value
1954	584,580	$67,882	664,706	$95,936	1,249,286	$164,818
1955	503,696	60,562	1,006,644	137,962	1,510,340	198,524
1956	579,734	43,776	1,101,432	109,446	1,681,166	158,222
1957	468,205	42,805	1,029,475	89,574	1,497,680	132,379
1958	433,463	41,218	612,302	75,034	1,045,765	116,252
1959	492,468	47,447	678,744	77,532	1,171,212	124,979
1960	273,936	38,407	449,636	69,693	732,572	108,100
1961	236,445	33,111	352,544	65,220	588,989	98,331
1962	218,149	28,348	309,531	49,525	527,680	77,873
1963	132,564	25,807	215,454	54,018	348,018	81,825
1964	78,084	16,993	103,781	20,720	181,865	37,713
1965	119,958	20,300	117,563	15,629	237,521	35,929
1966	67,908	9,346	48,424	5,811	116,332	15,157
1967	76,491	11,550	99,867	19,976	176,358	28,526
1968	113,100	19,896	141,272	26,079	254,372	45,975
1969	122,676	17,789	120,428	14,451	243,104	32,240
1970	95,900	12,176	135,671	20,630	231,571	32,806
1971	70,038	15,361	100,760	18,137	170,798	33,498

Source: Fisheries Statistics of the US, 1939-1971.
See Appendix III for earlier titles.

Appendix II-2 NYS Shad Landings by Gear, 1926-1971

					Gill Nets			
	Pound Nets		Haul Seines		Anchor/Set/Stake		Drift	
Year	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
1926	10,059	$1,741	--	--	Combined Gill Nets:		202,661	$43,560
1929	1,446	184	3,618	$618	10,067	$1,679	149,328	24,547
1930	283	48	1,148	223	17,173	3,763	148,372	24,168
1931	13,060	1,490	36,952	3,753	3,231	1,065	303,563	36,546
1932	2,988	259	1,350	150	51,560	7,361	344,597	33,468
1933	15,758	788	4,040	448	34,134	3,669	297,753	23,844
1934	--	--	--	--	--	--	--	--
1935	21,900	1,412	10,200	874	2,000	184	424,000	35,658
1936	--	--	--	--	--	--	--	--
1937	38,700	2,865	19,700	1,433	30,400	2,556	932,600	70,009
1938	98,800	5,050	11,600	620	14,900	815	946,000	52,554
1939	145,100	4,192	59,600	2,430	14,200	1,192	1,158,900	46,363
1940	84,400	4,100	15,900	848	416,400	21,473	865,400	44,382
1941	--	--	--	--	--	--	--	--
1942	258,900	20,864	2,900	200	513,600	35,696	805,200	45,659
1943	565,000	63,550	11,400	1,176	592,000	73,892	1,072,600	84,855
1944	446,100	29,260	28,500	2,099	566,900	35,549	1,088,000	55,565
1945	758,200	86,532	48,800	7,278	941,200	134,554	1,072,700	130,932
1946	206,500	46,362	23,300	3,506	571,400	85,705	849,600	129,035
1947	291,100	43,818	42,900	3,771	324,300	33,260	602,800	60,462
1948	267,500	46,362	65,600	8,391	443,700	57,015	612,400	81,291
1949	139,200	27,922	43,300	5,637	264,000	39,600	452,300	68,158
1950	213,600	42,498	27,900	4,464	144,900	21,732	240,800	35,816
1951	48,400	7,835	7,400	1,078	123,600	18,529	282,400	43,068
1952	282,600	50,246	6,300	900	116,800	14,240	367,600	44,490
1953	25,500	4,417	4,100	505	127,600	24,801	334,000	37,538
1954	121,600	19,776	4,200	615	188,500	28,423	390,600	38,677
1955	108,200	21,305	5,400	657	211,400	29,090	288,900	31,031
1956	120,900	14,508	3,800	336	343,700	24,104	234,100	19,552
1957	156,200	18,751	3,800	365	230,100	22,833	235,000	19,691
1958	211,000	33,540	2,300	306	210,500	20,508	220,700	20,404
1959	168,000	29,756	12,400	2,023	285,000	31,078	206,300	16,244
1960	143,500	28,660	3,300	324	127,200	20,535	143,400	17,548
1961	62,100	11,613	5,800	1,003	143,400	21,320	91,300	11,536
1962	23,500	4,548	3,200	373	103,400	15,054	112,400	13,077
1963	63,800	12,406	7,200	1,359	61,500	14,569	69,300	10,948
1964	62,500	6,399	200	20	45,300	9,227	32,900	7,716
1965	10,400	1,254	1,700	205	62,200	10,118	57,500	10,181
1966	10,900	1,120	0	0	28,900	4,001	39,000	5,345
1967	25,700	4,568	5,000	886	33,700	5,764	45,300	6,018
1968	9,800	1,601	2,600	428	45,400	8,728	67,700	11,168
1969	13,700	1,893	0	0	58,700	9,101	64,000	8,688
1970	9,400	796	400	36	48,700	5,844	47,200	6,332
1971	1,800	220	1,000	120	29,400	6,326	40,700	9,035

Data compiled by William Knapp of the Marine Sciences Research Center, SUNY at Stony Brook.

Appendix II-3 1973 Prices and Receipts for Shad, 1950-1971

	Primary Wholesale Prices (¢/pound)			Receipts (1000 pounds) to 8AM of market date								
Date	Roe	Buck	Cuts	Total	Ct	Ga	Md	NC	NY	Va	SC	NJ
Jan												
03								0.1				
08								0.7				
15						0.1						
18						0.1						
19								0.2				
23						0.1						
26						1.1						
30						1.4						
31								0.6				
Feb												
01						0.5						
02	65	35						0.1				
05						2.0						
08						0.9						
09	70	40				1.9						
13										0.1		
14								1.1				
15	75	35	58			5.2						
16						3.2						
20	75	35	55	7.9		7.8				0.1		
22	75	35				6.9						
23	55					0.6						
26	75	38	55	13.9		13.1		0.6		0.2		
27								0.4				
28								0.3				
Mar												
01	75	35	50			13.2						
02				2.9				2.7		0.2		
05				11.7		10.6		1.1				
06	65	30	40	17.2		16.6		0.1		0.5		
07				1.9				1.5		0.4		
08	65	30	40	5.1		3.0				0.9	1.2	
09				5.1				1.3		3.8		
12	65	25										
	50	23	35	23.4		10.2		3.2		6.6	3.4	
13	50	20	35	6.3		1.7				4.6		
14				4.0			0.8			3.2		
15	60	15										
	50	15	33	14.5		6.4	0.1	0.2		6.1	1.7	
16				8.4			0.2	1.0		7.2		
19	35	10	33									
	45	10		26.5		15.8	0.2			9.1	1.4	
20	30	10	33	12.6		1.0	0.4	10.1		1.1		

Date	Primary Wholesale Prices (¢/pound) Roc	Buck	Cuts	Receipts (1000 pounds) to 8AM of market date Total	Cn	Ga	Md	NC	NY	Va	SC	NJ
Mar (contd)												
21			28							5.7		
22	40	10										
	30	10	30	14.4		2.3	0.4	0.1		11.1	0.5	
23										8.3		
26	45		38	9.8		3.2		0.3		6.3		
27	45	15	35							9.9		
28	50	15	35	11.3			0.2			11.1		
29			40	10.5						10.2	0.3	
30				9.2		0.3	0.2			8.7		
Apr												
02	53											
	45	20	10	31.7		0.9		0.3		28.6	1.9	
03	40	18	35	35.5			0.5	0.3		34.7		
04	38	18	30	19.6			0.5	0.5		18.6		
05	33	15	28	10.9		0.5	0.9			9.0	0.5	
06				5.5				0.3		5.2		
09		11	28	22.8			0.4	0.2		22.2		
10			28	18.5			0.5	0.4		17.6		
11			25	8.2			1.5			6.7		
12	35		25	10.4			1.7	0.7		8.0		
13				5.8			3.7	0.1		2.0		
16	50		33	16.5			1.4			11.9		3.2
17	45	18										
	50		33	21.2			1.9		1.2	13.5		14.6
18			33	37.2			4.4	1.0	1.8	24.6		5.4
19			33	5.3			0.2		1.2	3.9		
23	23			29.3			1.0		10.8	11.6		5.9
24	23			29.9			3.0		4.6	12.2		10.1
25	23			24.5	0.8		9.2	1.3	6.1	4.5		2.6
26	23			23.7			10.5	0.2	6.3	4.2		2.5
27				18.5			8.5		7.5			2.5
30			15	22.1	0.2		4.5		1.8	1.0		14.6
May												
01			18	12.3			3.3			1.5		7.5
02			25	4.8	0.5				2.0			2.3
03			38	14.8	6.8			0.2	2.0	0.1		5.7
04				12.2	6.6				1.6			1.6
07			35	6.6	4.3		0.3		1.2			0.8
08			38	9.5	2.9				1.4	0.1		5.1
09			35	2.7	1.8				0.9			
10			35	11.6	6.9		1.0		1.8	0.7		1.2
11				8.6	5.5		2.5					0.6
14				4.8	4.3		0.5					
15	25		35	3.4	2.5		0.1					0.8
16	33	12		5.0	4.1					0.7		0.2
17	25			2.8	1.7		1.0			0.1		
20				4.9	4.5		0.1	0.1	0.1	0.1		
21	25	10		2.4						1.8		0.6

Date	Primary Wholesale Prices (¢/pound) Roe	Buck	Cuts	Receipts (1000 pounds) to BAM of market date Total	Ct	Ga	Md	NC	NY	Va	SC	NJ
May (contd)												
22				2.9	2.8				0.1			
23				0.2								0.2
24				1.9					0.4	1.5		
25				1.5	1.5							
29				1.7	1.1		0.6					
30				2.6	0.4		2.2					
31	40	15		1.3	1.3							
June												
01				1.1	0.6				0.5			
04				2.0					2.0			
05				2.6	1.0				1.6			
06	25	10		1.5			1.5					
07				1.2	0.7		0.5					
08				2.0					2.0			
11				0.1					0.1			
12				0.4					0.4			
15				0.2					0.2			
18				1.1					1.1			
19		15		0.6	0.2				0.4			
20				1.6					1.6			
21		15		0.3					0.3			
22				0.1					0.1			
26				1.7					1.7			
27		10										
July												
05				0.4					0.4			
11		15										

Source: National Marine Fisheries Service, 1973.

Appendix II-4 Annual US Production of Processed Shad, 1950-1971

	Fillets (lbs)		Canned				Smoked (lbs)	
	Fresh (Boned)		Fish (std. case)		Roe (std. case)			
Year	Quantity	Value($)	Quantity	Value	Quantity	Value	Quantity	Value
1950	--	--	19,049	89,851	3,723	263,187	66,365	22,228
1951	--	--	10,828	87,125	3,349	277,404	--	--
1952	--	--	8,040	60,607	3,444	167,680	144,000	52,150
1953	--	--	7,603	57,571	2,330	181,393	132,000	38,200
1954	--	--	4,042	33,332	2,440	225,919	106,557	25,637
1955	--	--	4,888	39,702	2,199	210,388	151,500	34,386
1956	--	--	7,168	52,712	8,122	185,001	144,600	35,606
1957	13,644	3,843	4,115	31,056	989	66,891	153,505	45,155
1958	--	--	4,960	35,739	909	74,872	86,361	26,935
1959	--	--	4,416	29,515	531	42,483	116,200	38,601
1960	33,750	11,174	3,418	37,462	862	97,034	80,000	24,775
1961	--	--	2,900	32,276	1,717	214,199	81,160	27,580
1962	(1)	(1)	14,494	167,714	2,597	249,673	72,900	22,790
1963	(1)	(1)	10,280	102,612	2,206	153,188	90,501	31,449
1964	84,336	58,214	* 1,235	10,886	670	38,592	94,600	38,840
1965	26,696	40,044	1,731	11,172	1,838	119,223	89,295	33,754
1966	(1)	(1)	7,460	59,223	1,384	122,117	67,667	23,689
1967	25,539	43,672	5,815	46,378	1,928	182,248	67,981	23,165
1968	31,815	63,947	1,190	9,622	1,082	128,566	56,617	19,820
1969	28,445	66,561	1,998	17,609	615	73,164	40,680	15,592
1970	25,601	60,418	*	*	523	70,097	32,000	15,450
1971	25,000	62,500	*	*	1,030	169,661	32,000	16,200

* "Less than three plants canned shad in 1970"...and 1971. For 1970 and 1971, the production of canned shad is recorded anonymously in the table "pack of miscellaneous fishery products" (Fisheries Statistics of the US, 1970, 1971).

Source: Fisheries Statistics of the US, 1950-1971.

Appendix II-5 US Production of Canned Shad Flesh, 1950-1971

Year	Number of Canneries	Standard Cases	Pounds/Case	Pounds	Value ($)
1950	6	14,049	45	632,205	89,851
1951	9	10,828	45	487,260	87,125
1952	6	8,040	45	361,800	60,607
1953	6	7,603	45	342,135	57,571
1954	3	4,042	45	181,890	33,332
1955	3	4,888	45	219,960	39,702
1956	7	7,168	45	322,560	52,712
1957	6	4,115	45	185,175	31,056
1958	5	4,960	45	223,200	35,739
1959	5	4,416	45	198,720	29,515
1960	7	3,418	45	153,810	37,462
1961	7	2,900	45	130,500	32,276
1962	9	14,494	45	652,230	167,714
1963	8	10,280	45	462,600	102,612
1964	5	1,235	45	55,575	10,886
1965	5	1,731	45	77,895	11,172
1966	3	7,460	45	335,700 *	59,223
1967	5	5,815	45	261,675	46,378
1968	3	1,190	45	53,550	9,622
1969	4	1,998	45	89,960	17,609
1970	*	*	*	*	*
1971	*	*	*	*	*

* "Less than three plants canned shad in 1970"...and 1971. For 1970 and 1971, the production of canned shad is recorded anonymously in the table "pack of miscellaneous fishery products" (Fisheries Statistics of the US, 1970, 1971).

Source: Fisheries Statistics of the US, 1950-1971.

Appendix II-6 Shad Processors by State, 1939-1971

Year	Calif. Shad	Calif. Roe	Oregon Shad	Oregon Roe	Wash. Shad	Wash. Roe	Florida Shad	Florida Roe	NC Shad	NC Roe	Virginia Shad	Virginia Roe	Maryland Shad	Maryland Roe	Maine Shad	Maine Roe
1939	All shad and roe processed in Pacific states.															
1940																
1941																
1942																
1943																
1944	3		4		2				1				4		1	
1946	natural		1				1						5		2	
	smoked		7		3											
1947																
1948	3	2	8	7	2	1	1	1	1		1	1	4	1		
1949																
1950	1	2	4	6		2							1			
1951	1	2	5	5		2			2				1	1	1	
1952	1	2	4	4		1							1	1		
1953	1	2	4	4	1									1		
1954		1	2	5		2							1	1		
1955		1	2	4		2					1		1	1		
1956	1	2	3	3	1	1			1		1			1		
1957		1	3	6		1			1		1			1		
1958		1	3	3		1			1		1			1		
1959			3	2	1	1					1			1		
1960		1	4	4	1	1			1				1	1		
1961		1	4	3	2	2			1					1		
1962		1	4	4	2	2			2		1			1		
1963		1	5	5	2	2							1			
1964			4	4	1	1										
1965		1	3	4	1	1					1					
1966		1	2	2	1	1										
1967		1	4	1	1	1										
1968		1	2	3	1	1										
1969		1	1	3	2	1					1					
1970	*	1	*	2	*	1										
1971	*		*	2	*	1										

* "Less than 3 plants canned shad in 1970"...and 1971. For 1970 and 1971, the production of canned shad is recorded anonymously in the table "pack of miscellaneous fishery products" (Fisheries Statistics of the US, 1970, 1971).

Source: Fisheries Statistics of the US, 1939-1971.

Appendix II-7 Canned Shad Roe, US Production, 1950-1971

Year	Plants	Standard Cases	Value ($)
1950	11	3,723	263,187
1951	10	3,349	277,404
1952	9	3,444	167,680
1953	7	2,330	181,393
1954	8	2,199	210,388
1955	9	2,440	225,919
1956	7	8,122	185,001
1957	9	989	66,891
1958	6	909	74,872
1959	4	531	42,483
1960	7	862	97,034
1961	7	1,717	214,199
1962	8	2,597	249,623
1963	8	2,206	153,188
1964	5	670	38,592
1965	6	1,838	119,223
1966	4	1,384	122,117
1967	6	1,928	182,248
1968	5	1,082	128,566
1969	5	615	73,164
1970	4	523	70,097
1971	3	1,030	169,661

SOURCE: Fisheries Statistics of the US, 1950-1971.

Appendix III Statistics Publications

Several federal agencies have collected federal fishery statistics. Among these agencies are the Bureau of the Census, Fish Commission, Bureau of Commercial Fisheries, Fish and Wildlife Service, and National Marine Fisheries Service. Elements of the following list of publications contain statistics on the fisheries of the Middle Atlantic states, notably New York State. Unless otherwise noted, all publications were issued most recently by the National Marine Fisheries Service, the Bureau of Commercial Fisheries, or their predecessors.

Data for:	*Title of Publication*
1880	The Fisheries and Fishery Industries of the US, Section II, Senate Document No. 124, 47th Congress, 1887
1887	Report of the Commissioner of Fisheries for 1888
1888	Report of the Commissioner of Fisheries for 1888
1889-1891	Bulletin of the US Fish Commission, 1894
1897	Report of the Commissioner of Fisheries for the year ending June 30, 1900
1901	Report of the Commissioner of Fisheries for the year ending June 30, 1902
1904	Report of the Commissioner of Fisheries for the year ending June 30, 1905
1908	Fisheries of the US, 1908, Bureau of the Census
1921-1938	Fishery Industries of the US, 1922-1939
1939	Fisheries Statistics of the US, Statistical Digest #1
1940	Fisheries Statistics of the US, Statistical Digest 4
1941	Fisheries Statistics of the US, Statistical Digest 7
1942	Fisheries Statistics of the US, Statistical Digest 11
1943	Fisheries Statistics of the US, Statistical Digest 14
1944	Fisheries Statistics of the US, Statistical Digest 16
1945	Fisheries Statistics of the US, Statistical Digest 18
1946	Fisheries Statistics of the US, Statistical Digest 19
1947	Fisheries Statistics of the US, Statistical Digest 21
1948	Fisheries Statistics of the US, Statistical Digest 22
1949	Fisheries Statistics of the US, Statistical Digest 25
1950	Fisheries Statistics of the US, Statistical Digest 27
1951	Fisheries Statistics of the US, Statistical Digest 30
1952	Fisheries Statistics of the US, Statistical Digest 34
1953	Fisheries Statistics of the US, Statistical Digest 36
1954	Fisheries Statistics of the US, Statistical Digest 39

Data for:	*Title of Publication*
1955	Fisheries Statistics of the US, Statistical Digest 41
1956	Fisheries Statistics of the US, Statistical Digest 43
1957	Fisheries Statistics of the US, Statistical Digest 44
1958	Fisheries Statistics of the US, Statistical Digest 49
1959	Fisheries Statistics of the US, Statistical Digest 51
1960	Fisheries Statistics of the US, Statistical Digest 53
1961	Fisheries Statistics of the US, Statistical Digest 54
1962	Fisheries Statistics of the US, Statistical Digest 56
1963	Fisheries Statistics of the US, Statistical Digest 57
1964	Fisheries Statistics of the US, Statistical Digest 58
1965	Fisheries Statistics of the US, Statistical Digest 59
1966	Fisheries Statistics of the US, Statistical Digest 60
1967	Fisheries Statistics of the US, Statistical Digest 61
1968	Fisheries Statistics of the US, Statistical Digest 62
1969	Fisheries Statistics of the US, Statistical Digest 63