A SURVEY OF FORMER SHAD STREAMS IN MAINE

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United States Department of the Interior, Oscar L. Chapman, Secretary
Fish and Wildlife Service, Albert M. Day, Director

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Special Scientific Report: Fisheries No. 66

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PREFACE

This report is the first of several to consider the problem of rebuilding the almost extinct shad runs of Maine to a size that will enable them to support profitable and stable fisheries again.

Within the last fifty years, the catch of Atlantic shad has fallen to less than a third of its former yield. Alarmed by the continued decline of this fishery, the Atlantic States Marine Fisheries Commission made repeated efforts to initiate a comprehensive coastwise study of the shad but it was not until October 1949 that Congressional action was finally obtained authorizing and providing funds for the work.(Public Law 249, 81st Congress). The Fish and Wildlife Service,as the primary research agency of the Commission presented the research program to an Advisory Committee of the Commission in December 1949 for review and approval.

One part of this program was to re-establish runs in former shad streams now barren in order to make these streams once more productive. The accompanying report gives information on the present stream conditions in the State of Maine, information which is necessary before any plans for rehabilitation of the shad runs of the area can be formulated.

In the preparation of this report, extensive use has been made of published and unpublished information collected by the Department of Sea and Shore Fisheries of the State of Maine; we wish especially to acknowledge the help given us by Mr. Richard E. Reed, Commissioner, and Mr. Frank T. Baird, State Biologist. This project is under the direct supervision of Mr. Gerald B. Talbot.

Clinton E. Atkinson
Chief, Middle and South
Atlantic Fishery Investigations.
Fish and Wildlife Service

May 10,1951

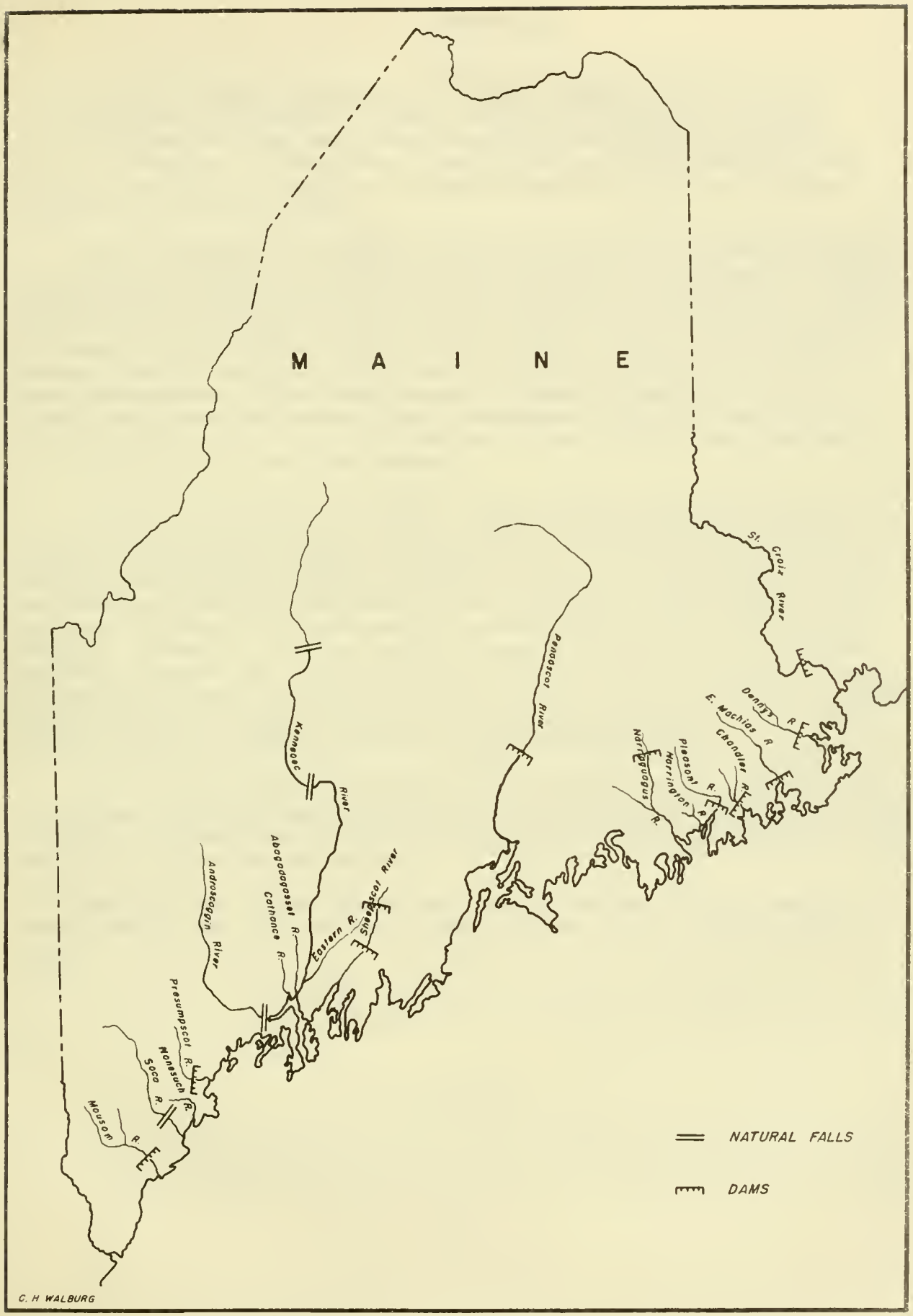

Figure 1.-- The state of Maine showing the former shad streams and the present limits to shad migration.

INTRODUCTION

A survey of Maine streams which formerly supported shad runs was conducted during the summer of 1950 to assess the factors contributing to the decline and complete, or nearly complete, extinction of shad in Maine, to determine to what extent these factors are still operative, and to investigate the suitability of certain streams as sites for stocking attempts at some future date.

Since practically no commercial fishery for shad has existed in Maine rivers for many years, and since only a comparatively small number of former shad fishermen can now be found from whom first-hand information can be obtained, it was necessary to rely heavily on historical accounts of shad and the shad fishery in Maine rivers for information concerning their former abundance and for evidence of the conditions which may have contributed to their disappearance. The annual return of tremendous numbers of shad to almost every river and stream of any consequence in Maine, as well as the early disappearance of this fish from many streams, did not go unremarked in the chronicles of the early settlements.

A review of historical accounts of shad in Maine rivers preceded the field survey, and this review proved valuable in indicating those rivers where field work could be done most profitably. Streams with no past history of shad runs were examined cursorily, if at all. Streams which once had important shad runs were examined more thoroughly, expecially in those instances in which the streams are not presently obstructed by artificial barriers. Rivers and streams obstructed near brackish water by impassable dams were examined only superficially. The major portion of the field work was devoted to those streams where small shad runs still exist, and to streams which formerly had runs of commercial importance and in which dams or other obstructions do not prevent access to former spawning areas.

Part I of this report considers the former shad rivers of the State in their order along the coast from west to east. Historical information, where available, is summarized for each river, together with a description of present conditions as revealed by field work.

Part II is an attempt to evaluate the various factors which may have contributed to the disappearance of shad from the various rivers of the State.

PART I

THE PAST HISTORY AND PRESENT CONDITIONS OF SHAD RIVERS IN MAINE

Mousam River

The Mousam River, arising at Mousam Pond about 24 miles from the sea, enters the ocean a few miles south of the village of Kennebunk, Maine. Atkins (1868, p. 26) states that the river once had salmon, shad, and alewives. Runs of all three species disappeared early. According to Atkins (1868, p. 26) the first dam on the Mousam was built in Kennebunk in 1675. It was rebuilt in 1720 further down the river and again in 1774 near its original site. A dam has been constantly maintained at Kennebunk since 1720 and in 1867 Atkins reported there were 18 mill dams and one reservoir dam between Mousam Pond and the sea.

The Mousam River was inspected on September 21, 1950. Two impassable dams were found just above and below the highway bridge in the village of Kennebunk. The river appeared to be affected by pollution at this point, a heavy green algal scum almost covering the river above the upper dam in Kennebunk. Between Kennebunk and the sea, the river, although unobstructed, is sufficiently polluted to cause the tidal area near its mouth to be closed to the digging of clams (Maine Sea and Shore Fishery Laws, p. 153, 1949).

Saco River

The Saco River arises in the White Mountains region of New Hampshire and enters the sea about three miles below Biddeford, Maine. A natural falls at Biddefort prevented the passage of all fish but salmon. Atkins (1868, p. 32) states that there had always been shad in the lower part of the river; "In 1850 two men took an average of 25-30 shad per night in a short time. This was enough to supply their market. From 1850 to 1860 there was not much fall off in catch. The last five years, shad have been very difficult to get". Atkins attributed the decline in the fishery to the presence of cotton and woolen mills and the pouring of dyes into the river.

Interviews with lobster fishermen operating from the Saco side of the river gave no indication of shad in the river in recent years. These fishermen were of the opinion that wastes from the textile mills would make the river unfit for shad.

Nonesuch River

One finds no mention of the Nonesuch River in the various accounts of shad streams in Maine, so that it may be presumed this river never supported a fishery of any importance. The Nonesuch River is of particular interest,

however, because it has at the present time a small but well-established run of shad which does not appear to have fluctuated notably within the last 30 years.

The Nonesuch River rises in the southwestern part of the township of saco and flows through sandy, rolling country to enter the sea between Pine Point and Prout's Neck on Saco Bay. Except for the small village of Scarboro, about two and a half miles from its mouth, there are no settlements and few houses along its entire length. The river is, therefore, practically free from all kinds of pollution. A sanitary survey of the lower five miles of this stream was made by the Maine Department of Sea and Shore Fisheries in September 1950, in an effort to locate the sources of domestic pollution of the clam flats in the Scarboro area. This survey indicated practically no domestic pollution above tidewater and very little above the village of scarboro.

The Nonesuch River was surveyed on August 22, 1950, from the town of Scarboro to Thurston's Mills about 18 miles from the sea.

The lower part of the Nonesuch, in its tidal portion, flows though marshland to U. S. Highway 1. Salinity samples taken at the highway bridge in Scarboro showed a salinity of less than 1/2 part per thousand just after flood tide. About two miles farther up, at U. S. Highway 1, the salinity was about the same. At Buggy Meetinghouse, above the influence of the tide, the salinity was only slightly less than at the two lower points. From Buggy Meetinghouse to the point where Broad Turn Road crosses the river about five miles up the stream, the river flows through sandy country. It is characterized by deep pools with sandy or gravelly bottom at frequent intervals between channels varying from 8 to 10 feet across with depths ranging from 18 inches to two feet. In approximately 17 miles between the sea and the bridge at Broad Turn Road, the river rises only 40 feet with no abrupt rises noted in the sections examined on foot. Between Broad Turn Road and Thurston's Mills, a distance of about one and a quarter miles, the difference in elevation is about 60 feet, 40 feet of this difference being just below Thurston's Mills. (Elevation data from the Maine Portland Quadrangle published by the Geological Survey).

A dam and sawmill at Thurston's Mills washed out in a freshet about 1917, according to a local resident. The stream at this point is now completely overgrown with alders, and the only trace of the mill is an old sill log across the bed of the stream. It is doubtful if shad ever ascended to this point because of the small size and steep gradient of the stream. This is confirmed through interviews with two local residents who remember the existence of the mill.

Interviews in the Scarboro area on September 21 with local residents who have caught shad in the Nonesuch yielded some information concerning the run of fish. The fish enter the river in early May and are caught to about the middle of June. The total catch in a night's fishing may run as high as 20

to 30 fish with the season total variously estimated between 200 and 400 fish. As many as 40 persons my be found fishing in a single night. The usual gear is a dip net between five and six feet in diameter.

The taking of shad in the Nonesuch is restricted by law to dip or bag nets not exceeding 19 feet in circumference or to artifical fly. Fishing is permitted only in the tidal portion of the river south of U. S. Route 1. The daily catch limit is five fish. (Maine Sea and Shore Fisheries Laws and Regulations 1949, p. 103).

Presumpscot River

The Presumpscot River once had a shad run, although no information on its size and importance has been found. Presumpscot Falls, one mile from the sea, was passable to shad according to Atkins. A dam was built at this point in 1802 and remained there until 1852. In 1867 Atkins (1868, p. 33) reported shad ascending the river to Cumberland Falls, nine miles from the sea, where a 9-foot dam prevented further passage.

The dam of the S. D. Warren Paper Company at Westbrook completely obstructs the river and the waste products from this mill may have discouraged the return of shad to the lower river.

A survey of river and stream conditions in 1930 (Walker, p. 14, 1930) indicated that at least one point between Westbrook and the sea had a dissolved oxygen content which fell below three parts per million, attributable to sulphite wastes.

Stroudwater River

The Stroudwater River is blocked just above tidewater by a masonry dam about 10 feet high. No mention of a shad run in this river has been found in the various records examined.

Royal River

An impassable dam about 1/4 mile above tidewater bars the ascent of fish in the Royal River. Atkins does not mention this river as having shad and it is possible that rapids just above tidewater formed a natural barrier.

Kennebec River

The Kennebec River once supported the principal shad fishery in Maine and this fishery continued to flourish for many years after the shad had become all but extinct in the other rivers of the state. In addition to shad,

which far outranked the other fisheries of the river, salmon, sturgeon, alewives, and smelts were also fished commercially.

In its original condition, shad ascended the Kennebec and its tributaries until limited by natural barriers or conditions. Although Stevenson (1897, p. 270) indicates that the original limit of shad on the main Kennebec was Caratunk Falls, 108 miles from the sea, Atkins' statement (1868, p. 48) that the natural limit was Norridgewock Falls, some forty miles below Caratunk, is probably correct. A part of the run ascended the Sandy River, which enters the Kennebec at Norridgewock, as far as the town of Farmington (Parker, 1875, p. 7). The lower part of the Sebasticook River, a tributary entering the Kennebec between Augusta and Waterville, had a profitable shad fishery and the fish were reported to go up this river as far as the town of Newport (Atkins, 1889, p. 719).

The tributaries were early cut off by the construction of dams. Cobbosseecontee Stream was dammed at Gardiner in 1787 (Atkins, 1868, p. 52). Efforts to maintain the runs of fish were of no avail:

> "In the old records of the town of Monmouth, then called Wales, we find that in 1787 a "fish committee" was chosen, consisting of three men; and in 1788 they are styled "Committee to see that the fishways are kept open according to law." They were appointed as "Fish Committee" each year until 1806, when they cease to be mentioned." (Atkins, 1868, p.52).

According to Atkins, (1868, p. 54), the Sandy River maintained an excellent shad fishery for some years after a dam was built at New Sharon in 1804 which limited the fish to the lower part of the river.

In the town of Clinton (now Benton) on the Sebasticook River, a dam was built in 1809, 12 feet high with no fishway. This dam stood for five or six years and "had so impoverished the fisheries that the selectmen cut it away and allowed the fish to ascend to their breeding grounds" (Atkins, 1868, p. 53).

"In 1814 the town obtained the act authorizing them to control the fisheries and the first year after cutting away this dam, the fishery was leased to one James Ford, he agreeing to pay yearly 200 fish to each man, woman, and child in Clinton, and to sell as many more as he wanted at a fixed price. From this time the fishery increased rapidly and the town began to sell the fishery yerly at public auction. The price varied from $500 to $1200-$1500; the purchaser being bound to distribute gratis to the poor and to sell to all the townspeople at a fixed price. The year of the closing of the August dam the fishery sold for $225. One or two years before it had sold for $500." (Atkins, 1868 p. 54).

The event having a major effect on the fisheries of the Kennebec was the construction of the dam at Augusta which closed the entire river above tidewater. The Maine legislature was petitioned in January 1834 for incorporation to build a dam, and an act incorporating the Kennebec Dam Company was approved March 7, 1834:

> "Hostility soon appeared to the project, and the charter was not obtained without considerable effort. At the time appointed the committee of the legislature 'listended with the utmost patience to numerous petitions and remonstrances from various parts of the state'..... and having classified the objections under three heads, reported a bill. The first objection was on account the fisheries, which it was feared the dam would destroy; the second related to the navigation of the river, which would be injured for boats and rafts of lumber; and the third represented that in times of high freshets the village of Winslow and the mills at Waterville would be flowed." (North, 1870, p. 571).

The bill passed by the legislature provided for a dam fifteen feet high, with a lock 100 by 28 feet, a sluice-way of 60 feet for lumber, and a fishway. Work was started in 1835 and the dam was finally closed September 27, 1837. When completed, the dam was 600 feet long between abutments, and 16 feet above ordinary high water. The provision for a fishway was ignored. The lock was completed October 12, 1837. (North, 1870, p. 579).

The new dam was seriously breached by a freshet in January, 1839. The breach was not closed until 1841:

> "Salmon, which had a free passage to ascend the river during the two seasons the dam was open, were caught in great numbers after it was closed in 1841. One night in June of that year, 150 were taken at Augusta of an average weight of 17 pounds each." (North, 1870, p. 610).

Although serious breaks in the dam occurred in 1855 and again in 1870, these were repaired almost immediately.

In the year 1846, a cotton mill and six sawmills were put in operation at the dam. By December 1847, "ten saws upon the dam and two saws in the steam mill were running night and day". (North, 1870, p. 639).

The date of the first attempt to build a fishway over the dam is not known exactly but from the following account by Atkins (1868, p. 50) and from information obtained in North (1870, p. 697), the probable date is some time between 1855 and 1867:

"The dam at August is the most formidable of these (artificial obstructions). It creates a head of 17 feet. It is quite insurmountable by any kind of fish. The few salmon and alewives seen above August since its erection must have passed through the lock. A fishway was constructed over the dam some years ago, under the supervision of the Board of Fish Wardens. It was located at the west end of the dam. Considerable expense was laid on it, but through some fault of construction it was not capable of withstanding the force of floods, and of floating logs which always accumulate at that end of the dam. The first freshet wracked it badly and opened such seams in its cemented bottom that the water was wasted before it reached the foot of the fishway. Another freshet completed the work of destruction. The structure, therefore, never had a fair trial." (Atkins, 1868, p. 50).

When it became necessary to replace the 160-foot section of the dam swept away in February 1870, pressure was applied to the dam owners to build a fishway. The historian North appears to have expressed the attitude toward fishways prevailing in his day in the following account:

"When the proprietors were ready to move they requested the assistance of the city to relieve them from the burden and damage of a fishway which the law required to be made, and which competent authority was urging them to build. The law relating to fishways was doubtless passed by the legislature without knowledge of its operation upon enterprises of the magnitude contemplated at Augusta. Here is a dam nineteen feet high above tide water, on a large river, subject to sudden and great rises, upon which a large manufacturing capital is to be invested by the most wealthy and experienced manufacturers in the country. This, if successfully carried out, will be of incalculable value to the valley of the Kennebec and the whole state, and while encouraged by wise and fostering laws, should such enterprises be subject to other laws creating serious obstacles to their execution? Can it be doubted that the permanent interest of the States is to foster manufactures rather than the inferior fisheries? One gives constant and profitable employment to industry almost unlimited to extent, and in its operation stimulates every other branch of business; the other is limited in its operation to a short period of the year, and does not so directly promote any other interest. If it should be said that each may be fostered without injuring the other, it should be recollected that capitalists will not be persuaded that it can be done, and will shun our State if, in exhibiting its unrivaled water powers, it should show the irritating and burdensome incumbrances of fishways inseparably connected with them." (North, 1870, pp. 790-791).

A fishway was built and was in operation in 1898: "A fishway has been placed in this dam at its eastern end but it does not appear to be used by shad." (Stevenson, 1898, p. 265). At the present time there is no fishway in the Augusta dam.

Although the closing of the Augusta dam had an immediate and drastic effect on the fisheries of the Kennebec above Augusta, the only immediate effect below Augusta was the disappearance of the salmon, there being no suitable spawning areas for this species in the tidal river below Augusta.

The decline and eventual disappearance of shad from the lower Kennebec appears to have been a gradual process, the progress of which was not entirely realized because the catch figures did not reflect the decline which was occurring. The decline was noted in the Augusta area around 1860: "In 1822, in one day a seine was known to take 700 shad. About 1857 a seine took yearly 3,000 shad and 20,000 alewives. In 1867 the shad fishery was a total failure." (Atkins, 1868).

The total catch figures, both for the Merrymeeting Bay area and for the entire river, do not reflect the decline which was occurring, although Atkins cites the catch of a single weir in this district which apparently shows a decline in catch associated with the closing of the August dam: "Mr. Brown's weir produced in the ten years ending in 1835 an average of 5,961 shad yearly; in the twelve years from 1837 to 1848 (1844 being omitted from the record) the average was 3,120 per year, a little more than half the former yield." (Atkins, 1889, footnote, p. 720).

Atkins (1868, p. 44) estimated from records of fish inspected in the district of Bowdoinham, Woolwich and Dresden (Merrymeeting Bay district) for the years 1830-1836 that 1,000 barrels of 120,000 shad were caught in the district each year. In 1867, he estimated that the same district produced 180,000 shad per year, while the estimated catch for the whole Kennebec in the same year was 225,000 (Atkins, 1868, p. 40).

At a later date, Atkins (1889, p. 719) states:

> "The most productive shad weirs are those of the Merrymeeting Bay and its vicinity. Of the 140,000 shad taken in the Kennebec in 1880, 108,000 were taken in the Merrymeeting Bay district, 5,800 above Richmond, 16,744 between the bay and Bath, and only 10,000 below Bath, including the Sasanca or eastward arm, between Woolwich and Arrowsic. In the bay district, 44 weirs averaged 2048 shad, below Bath 29 weirs averaged 345 shad. All included in the above statement are breeding shad, called by the fishermen 'river shad' or 'spawn' shad."

As Atkins points out, the catch in 1880 was "accomplished by the use of a great number of far more efficient implements." The seine weirs were introduced in 1851 and 1852, entirely replacing the shoal-water weirs. Where the construction of seine weirs was impossible, "the catch of shad has fallen off remarkably since 1830". (Atkins, 1889, p. 720).

Tributaries of the Kennebec Entering Merrymeeting Bay

Merrymeeting Bay is formed by the confluence of two major rivers, the Androscoggin and the Kennebec, and several smaller streams. Except for the river channels, the bay is relatively shallow with the bottom varying through sand, gravel, and mud. Large "grass" areas of aquatic vegetation make it an important feeding area for ducks and geese during the spring and fall migrations. The mean range of tides is about five feet (U. S. Dept. Commerce Tide Tables, 1950). The great volume of fresh water entering the bay makes the bay almost completely fresh water except for the area near its outlet at "The Chops". In former times, an appreciable salinity was said to invade the bay during periods of low water flow during the summer. The controlled flow of the rivers today, through the systems of dams extending to their sources, appears to have lessened this effect. According to Stevenson, Merrymeeting Bay was a spawning area for shad: "Merrymeeting Bay, by reason of its broad, sandy flats, is also a favorable place for shad spawning" (Stevenson, 1898, p. 265).

The Androscoggin River enters the bay from the southwest. While never a shad river, because of impassable falls at Brunswick, the five-mile stretch between Brunswick and the bay was regularly fished. The Androscoggin River is now heavily polluted with all types of pollution from Brunswick to Berlin, New Hampshire, so that it has become entirely unsuitable for all kinds of fish. Pollution has become sufficiently serious to require corrective measures in such cities as Lewiston-Auburn during the summer months to reduce the stench sufficiently to make its course through these cities habitable (personal conversation with Dr. William Sawyer, Jr., Chairman, Department of Biology, Bates College, Lewiston, Maine). Fishermen and others in the Merrymeeting Bay area believe the Androscoggin is the chief source of pollution in the Merrymeeting Bay area and consider the Kennebec itself to be quite suitable for fish.

The Cathance River enters the bay on its western side. This river was formerly an important one for shad fishing, both below and above the town of Bowdoinham.

Two former shad fishermen were interviewed in the town of Bowdoinham. These men stated that the Cathance was fished from the railroad trestle about three and a half miles above Bowdoinham to the bay. The best fishing was from the "middle" and "upper middle" grounds, about a mile and a half above Bowdoinham, to the bay.

One of the fishermen stated that the last good catch of shad in the Merrymeeting Bay district was in the Spring of 1918. He remembered the date not only because of the good fishing but also because, newly married, he was living with his wife's parents while fishing the Abagadasset River that spring. "The next year there was nothing and there's been nothing since," he stated.

One of these fishermen related that his frequent reminiscing about the old days of good shad fishing led his sone to purchase some old gill nets which they repaired and tried about 1940. "I didn't think we would catch anything but I wanted to show him how it was done," he said. To his surprise, they aught six shad the first night they drifted in the Cathance below Bowdoinham. Father and son fished the nets for the next four years, finding a ready market for their small catches, which never exceeded 13 shad in a night. Eventually the nets were torn beyond repair and they did not feel the yield from their efforts justified buying new nets.

Both fishermen believe there are still small numbers of shad in the Cathance River, although no one has attempted to fish for them in recent years. They stated that smelts, eels, and suckers were profitable fisheries for some time after the disappearance of the shad but these species are no longer sufficiently abundant to pay one for fishing them on a commercial basis.

When asked why he thought the shad disappeared, one fisherman attributed it principally to the silting over of the bay. He stated that silting in the past 30 years would make it necesssary to fish nets 30 meshes deep in places where 40-mesh nets were formerly fished. He also added that he believed shad would come back except for the pollution from the Androscoggin, which he felt discourages their entrance into Merrymeeting Bay.

To check the statements concerning silting in the bay, U. S. Coast and Geodetic Chart No. 314 published in 1878 was compared with Chart No. 314 published in 1950, the latter embodying the most recent survey results and soundings. As far as could be determined, no significant changes in the depths in the bay can be found. Soundings were compared for several one-fourth nautical square mile areas. In some instances the average depths were greater on the more recent chart but this appears to have been caused by a tendency in the more recent survey to concentrate soundings in the channels with a few soundings to indicate shoal areas. Point by point comparisons, where possible, indicated little, if any, changes. Sand areas, where indicated, correspond on the two charts. The 1950 chart shows grass areas not indicated on the earlier chart but which in all probability were there.

The Cathance River was surveyed by boat on September 21,1950, between the bridge in Bowdoinham and the railroad trestle. Above the "upper middle" ground the river narrows to 50-75 feet with sand and gravel bottom interspersed with stretches of mud. The banks of the river are wooded, with ledges coming down to the water's edge and with occasional stretches of marsh. Near the railroad trestle, the channel becomes too narrow and shallow for the use of an outboard motor. Many pickerel and smaller fish were observed in the upper part of the river. No evidence of any kind of pollution was observed in the lnegth of river covered. A fertilizer plant near the bridge in Bowdoinham dumps no refuse in the water, according to local residents.

The Abagadasset River enters Merrymeeting Bay on its northern side on a course parallel to the main Kennebec. The tidal portion of this river is about

three and one-half miles long, after which the river becomes only a small brook with a flow estimated at about one gallon a minute when examined on August 27, 1950. A sawmill (Dinsmore's Mills) with a dam approximately 10 feet high existed at the head of tide at one time. Only the abutments of the dam remain. A wide pool with depths up to 10 feet just below the site of the sam showed sawdust and bits of wood on each of about six soundings with the lead. The exit from the pool into the channel of the river is narrow with a swift tidal current. No evidence of sawdust was found in any soundings below this point.

The first mile of the Abagadasset above its entrance on Merrymeeting Bay was found from soundings to be entirely soft mud. Beginning just below the railroad trestle, the mud gives way to sandy mud and stretches of fairly clean sand. The upper part of the river, except for the intertidal portion on the sides of the channel, is a firm sandy mud. No gravel areas were found.

The sides of the river are marshy, with minor exceptions. The more abundant flora are pickerelweed (Pontederia cordata), arrowhead (Sagittaria latifolia), several species of Potamogeton, wild rice (Zizania) and rushes (Juncus sp.).

There is only one house on the entire tidal portion of the river, so that sources of pollution are negligible.

The Eastern River, while not flowing directly into Merrymeeting Bay, is usually considered a part of the Merrymeeting Bay district. This river, with a tidal portion about 10 miles in length, enters the Kennebec on the eastern side of Swan Island. The river was one of the most productive areas of the Merrymeeting Bay district. Stevenson (1898, p. 267) states: "In the Eastern River thirty years ago, there were 8 or 9 weirs, each of which took 6,000 to 8,000 shad per year and about the same amount was taken by seines and drift nets, indicating a catch of 100,000 shad annually."

The Eastern River was surveyed by boat on September 5 and 7, 1950. On September 5, the portion from the bridge on Route 197 to Merrymeeting Bay was covered by boat. On September 7, the portion from the same bridge was similarly covered to a point about one and one-half miles above the village of Dresden Mills. The upper three miles of the river were not surveyed by boat but the river was examined at several points where it is accessible by car, and additional information was obtained from local residents.

Results of soundings on the Eastern River indicate that it has a greater proportion of sand and gravel bottom than either the Abagadasset or the Cathance rivers. Bottom soundings were made at thirteen stations. Eight of these stations indicated sand and gravel, three showed a sandy mud, and only two showed a soft mud. The upper three miles of the river were reported to be mostly mud bottom but one point was found to be a rather firm sandy mud.

The flora of the Eastern River differ in several noticeable respects from those of the Abagadasset and Cathance rivers. Where pickerelweed (Pontederia) and arrowhead (Sagittaria) predominate in the latter two rivers, these forms are much less abundant in the Eastern River. Wild rice (Zizania) on the other hand, is very abundant, covering acres of the bordering marshes. Sedges (Scirpus sp.) and rushes (Juncus sp.) were more frequently observed. Entirely aquatic vegetation, such as Potamogeton, Naias, and Vallisneria, was more plentiful than in either the Abagadasset or the Cathance. In shallow areas, a thick matting of a filamentous green alga was observed. One former shad fisherman interviewed on the river remarked about this growth, stating that it was unusual, and had been noticeable only the past two years.

One sucker fisherman, a Mr. Lemarr, was interviewed. He stated that he had not fished for shad for some eight or nine years. Before that time, he had caught a few shad each spring with drift gill nets, but when his nets eventually rotted out he did not consider it worthwhile to replace them.

Sturgeon were reported seen by three different persond ruing the past summer. Their presence in the river was not considered unusual. According to one report, certain local residents claim to be able to get sturgeon at any time they want them by dynamiting the deep holes of the river.

An alewife run exists in the Eastern River and was reported to be unusually noticeable the spring of 1950, although apparently no attempt was made to catch any, such attempts requiring suitable seines or weirs. One resident of the lower river, a Mr. Mayers, reported that thousands of alewives were killed in May, 1950, when piling was dynamited at the old lower bridge to clear the channel for navigation.

The Eastern River is noted for the excellence of its winter smelt fishery. During the past three winters, however, the smelt fishing has been very poor. The decline in the catch of smelts cannot be attributed to any unique condition in the Eastern River. Mr. F. T. Baird, Jr., Main Department of Sea and Shore Fisheries, in charge of smelt investigations, states that a similar decline has been reported all along the Maine coast.

Sheepscot River

The Sheepscot River enters the ocean through a long tidal estuary a little east of the entrance of the Kennebec River. The two rivers are connected between Bath and Hockomock Bay by a navigable channel, the Sasanoa River.

Atkins (1889, p. 719) writes:

> "The Sheepscot drains about 200 square miles. Its tributary lakes are few and small, and it seems to have been, as tradition asserts, frequented by salmon and shad to a greater extent than any

other river between the Kennebec and the Penobscot, while alewives were relatively less abundant. Impassable dams at Alna, at the head of tide, have for many years shut the migratory fishes out from nearly its entire course. The main river was exempted from the operation of the fish law by the act of legislature of 1800. This exemption did not extend to Dyer's River.

At present, the fisheries of the Sheepscot are of little importance, the total value of the product being but $2,540, which is about the ninth part of the Damariscotta. About 1,000 shad were taken in traps arranged for them in the river near Alna. One or two salmon are commonly taken in these shadnets, but none in 1880. No alewives of consequence are caught, there being no fishing specially for them, and no summer weirs built. Bass, smelt, and eels are the species taken for market."

A 12-foot concrete dam at Headtide, just above Alna, obstructed the passage of all fish until the spring of 1949 when the sawmill at the dam was completely destroyed by fire. Following this, the gates at the east and west ends of the dam were removed, and, for a while, the river was open to the passage of fish. The west gate was soon obstructed by debris and the east gate became obstructed to a lesser extent. The dam owner has been unusually uncooperative in keeping these gates free, as required by law; the members of the county Fish and Game Association are not permitted to clear the gates through their own efforts; and mill property on both sides of the river is posted with no trespassing signs.

There are dams at Whitefield, about five miles above Headtide, and at Cooper's Mills, about 15 miles above Headtide. The dam at Whitefield is in very bad condition and probably offers on serious obstruction to the passage of shad, salmon, and alewives, both through the fishway in the west end and through the old millrace. Because the dam diverts the flow of the river toward the millrace, and because this is constricted, it is possible that shad might have difficulty in negotiating this passage at time of high water. The dam at Cooper's Mills is impassable, although a fish ladder for salmon was being built in the summer of 1950.

The river between Alna and Cooper's Mills is predominantly sand and gravel bottom and offers suitable spawning areas both for the salmon and shad. While the salinity at the town of Sheepscot, about five miles below Alna is sufficiently high for the growth of such plants as Fucus vesiculosus, the river at Alna is completely fresh. The lamprey, Petromyzon marinus, spawns in the river, just above the bridge at Alna.

The short stretch of fresh water (about one and onehalf miles) below the dam at Headtide has maintained a small run of shad through the years. The river was fished regularly by the late Rockwell Riddle, Alna, Maine. Mr. Baird, Maine Sea and Shore Fisheries Department, measured two fish caught by

Mr. Riddle in June, 1948. A male, 18-1/2 inches long, weighed two pounds, while a female of the same length weighed three pounds.

During the spring of 1950, three fishermen are known to have fished for shad in the Sheepscot River by gill net. Calvin M. Cheney, Headtide, caught three fish. Harold Averill, Jr., caught four. A third fisherman was reported by Mr. Cheney as having caught five or six.

Dyer River

Dyer River enters the Sheepscot River at the village of Sheepscot. There is no record of shad having been caught in this river, although alewives ascend to its source at Dyer Pond. Atkins (1889, p. 716) reported a striped-bass fishery in its lower part.

The river was examined on foot on September 6, 1950, from the head of tide at North Newcastle to State Highway No. 215, a distance of four miles. The remains of an old dam at North Newcastle obstruct the stream but the obstruction could be removed easily. For about a mile and a half above North Newcastle, the stream, though small, might be passable for adult shad under spring highwater conditions. Above this point a series of beaver dams obstruct the stream, although they provide a wide and deep channel to within about three-quarters of a mile of Route 215.

Sheepscot River to Penobscot River

Between the Sheepscot River and the Penobscot River, there are no streams which had, in the past, shad runs worthy of mention. Small size, steep gradients, and natural falls probably account for the absence of shad.

The Damariscotta River has supported a valuable alewife run for many years. The river was not surveyed because of a natural falls just above the entrance of the river into salt water.

The Georges River may once have had a shad run. Eaten (1851) mentions shad and alewives in the table of contents of his "Annals of the Town of Warren" but the text refers to alewives only. An impassable dam has been maintained at Warren since the earliest settlement of the town. A fishway provides passage for alewives. The alewife run is one of the better ones remaining in the state. Brackish water extends nearly to the dam at Warren.

The Oyster River, a tributary to the Georges River, was examined on August 17, 1950. An impassable falls about 15 feet in height was found a short distance above the limit of brackish water.

The Ducktrap River, just east of Lincolnville, has a steep gradient a short distance from the sea. The swift flow over a shallow, rocky bed appears to make the lower part of this river entirely unsuitable for shad.

The Passagasawaukeag River at Belfast is the last river of any size between the Ducktrap and Penobscot. There is no recorded account of shad ever having been caught in this river. A concrete dam about 10 feet high at Holmes Mill without a fishway makes the fresh-water portion of the river inaccessible to shad.

Penobscot River

Historical accounts of shad in the Penobscot River indicate that dams alone were the principal factor exterminating the run of shad. Industrial pollution, principally from pulp and paper mills, did not become important until long after the construction of dams. Since the original dams were built to provide power for saw-mills, there is a possibility sawdust pollution may have contributed to the decline. The available evidence suggests, however, that the decline in numbers was immediately associated with construction of dams and was not caused by the accumulative effects of pollution.

The process began with the damming of the tributaries. The Segeundedunk was dammed in April 1771 (Ford, 1882, p. 522). A map of Bangor in 1820 (Ford, 1882, p. 539) shows a dam near the mouth of Kenduskeag stream. This dam was probably built about 1795 when a sawmill was erected at the head of tide (Ford, 1882, p. 539). in 1830, the main river was dammed at Oldtown which "seriously hindered the passage of shad and alewives" (Atkins, 1889, p. 709). About 1835, a dam was built at Veazie which closed the main river below Oldtown. This did not completely obstruct the passage of fish:

> "By the gradual washing away of the left bank of the river, there was uncovered a crevice in the ledge which enabled salmon to ascend, and they were thus preserved from complete destruction, but shad and alewives never recovered, though there is evidence that shad sometimes, in small numbers, passed both the above dams. Very soon after the building of these dams a rapid decline in the fisheries began. The shad fishery was in a few years utterly extinguished." (Atkins, 1889, p. 711).

Writing of the period about 1794, Ford (1882, p. 539) states:

> "Fish, too, began to be a marketable commodity. The streams were full of them. Salmon, shad, and alewives were taken under Lover's Leap, at the mouths of the Mantawassuck, Segeundedunk and Sowadabscook streams and at Penobscot Falls.

"No record was made of the quantity or value of fish taken in any one year, but between thirty and four hundred barrels of shad and alewives were usually taken at one tide at each of the several places or eddies - the average would be from 75 to 100 barrels. At Treat's Falls sometimes 40 salmon were taken in a day.

"The fishing season, in the spring, continued about five weeks; time of greatest plenty, two weeks. Salmon were taken during three months at least, but they were not too abundant. From $1 to $1.25 per barrel were paid from the vessels for alewives, and what were then considered fair prices for shad. Newburyport vessels were engaged in the trade and took large quantities of fish to Southern markets and the West Indies for plantation purposes." (Ford, 1882, p. 539).

Describing events in Bangor for the year 1827, Ford wrote:

"Some opinion may be formed in regard to the immense quantities of fish in the Penobscot at the head of tide, when it is understood that 7,000 shad and 100 barrels of alewives were taken at one haul of the seine, about the middle of May this year. This was an unusual fish year. Shad were sold at Oldtown at 5¢ a hundred, and alewives were deemed hardly worth saving." (Ford, 1882, p. 635).

By the time the Bangor Dam of the Bangor Water Works was completed in 1877, a shad fishery had ceased to exist. Because brackish water back up nearly if not quite to the city of Bangor, there are no suitable spawning areas for shad between the Bangor dam and the sea.

Narraguagus River

The Narraguagus River, although free from barriers to the passage of fish to the Beddington dam and although one of the best remaining salmon streams in the state, has no record of a shad run. Because it offers access to suitable spawning areas and because it is almost completely free from pollution, the river might be considered as a possible site for stocking attempts at some future date. (particularly in view of the fact that the Beddington Dam was breached in 1951).

Pleasant and Harrington Rivers

The Pleasant and Harrington river estuaries yield some shad each year. In an interview with coastal warden Bertram Davis, South Addison, it was learned that there are two or three local fishermen who drift for a short period in late May and early June. Fishing comes to an end when lobster traps placed in the area interfere with drifting operations. No estimate of the catch could be obtained. The fish are consumed locally.

The dam at Columbia Falls on the Pleasant River is only a few feet from salt water. The Harrington River is small and has a steep gradient. Neither river appears to offer any possibility of development as a shad river.

Chandler River

Atkins (1889, p. 702) states that the Chandler River once yielded salmon, shad, and alewives. A dam at Big Falls, four miles from Jonesboro, obstructs the river. At one time a dam existed at Jonesboro which prevented the passage of fish into the fresh water portion of the river. This dam has almost entirely disappeared and no longer obstructs the channel.

Machias River

The gorge at Machias apparently prevented this river from becoming an important shad stream. The gorge has been improved recently to facilitate the passage of salmon but a dam just above the gorge would prevent shad from reaching suitable spawning grounds.

East Machias River

The East Machias River is one of the principal alewife-producing streams of the state. A dam in the village of East Machias is provided with a fishway. According to Atkins, the East Machias River never produced more than "scattering specimens of shad".

Dennys River

Atkins (1868, p. 68) states:

> "In its primitive state this river abounded in salmon, shad and alewives. The shad disappeared early but the salmon and alewives continued to ascend the river until 1846. Since the first settlement of the country there has been a dam at Dennysville, near the mouth of the river, but a broad wasteway through a natural channel at one end of it allowed the passage of fish. But in 1846 a dam was erected one mile above, which was quite impassable. The alewives were so nearly extinguished that it was the general impression that not one was left; a few were, however, occasionally seen by persons above the falls. The salmon could still breed in limited numbers below the dam, and were never entirely destroyed. In 1858, these upper mills were burned and the dam destroyed. This allowed the fish again to ascend the river, but the alewives were still shut out from Meddybemps their natural breeding ground, by a dam at the outlet."

The Dennys River is now open to Meddybemps Lake. The river supports a small salmon run and might possibly support a shad run if restocked. It is entirely free from industrial pollution and there is a minimum of domestic pollution.

St. Croix River

In its original condition the St. Croix river is said to have abounded in salmon, shad, and alewives. Atkins (1868, p. 69) states: "The number of shad were almost incredible". The river was completely closed in 1825 "and the fisheries instantly fell off". (Atkins, 1868, p. 70). The river is now completely obstructed by a series of impassable dams beginning just above the head of tide at Calais to its source.

PART II

FACTORS ASSOCIATED WITH THE DECLINE OF SHAD IN MAINE

It is evident from the accounts of shad runs and their decline as given in Part I of this report that the principal factor which has operated to extinguish shad runs from Maine streams has been the construction of impassable dams which barred the fish from their spawning grounds. The State was settled along the coast, the sea providing a convenient highway to the colonies to the south. The need for water power for grist-mills and the development of lumber resources led to the early damming of the smaller streams near their entrance to salt water. With growth and development of suitable resources, it became possible to construct dams on the larger rivers, thus completing the destruction of the runs of fish in them. Where dam construction excluded the shad from suitable spawning areas, the fishery for them ceased almost immediately.

The shad fishery of the Kennebec River persisted for many years following the construction of the dam at Augusta in 1837 because a considerable area of fresh water and suitable spawning bottom remained below the dam, including Merrymeeting Bay and its tributaries. For over 60 years, this area produced several hundred thousand pounds of shad annually, with no noticeable decline in catch until the early 1900's. Atkins, however, presents data which indicate that the effect of the Augusta dam was to reduce the abundance in the lower river, an effect which might well be expected since over half the spawning area of the Kennebec was cut off by the August Dam. (See p. 9). Greater exploitation and the use of more efficient gear (the seine weir, p. 9) kept the catch at a high level, however, so that the reduction in abundance was not obvious. The catch in the vicinity of Augusta, nevertheless, had become practically nonexistent by 1867 (p. 9).

Table 1.—Statistics of the Maine Shad Fishery, 1887-1949

Year	Federal Statistics		Maine Statistics	
	Pounds	Value	Pounds	Value
1887	1,095,720	$27,330	—	—
1888	839,256	24,368	—	—
1896	366,738*	30,778	—	—
1898	861,879	19,752	1,152,000	$23,720
1900	—	—	820,400	22,704
1901	—	—	731,000	19,335
1902	848,999	28,959	773,400	26,722
1903	—	—	1,143,600	37,418
1904	—	—	1,259,400	49,481
1905	667,256	42,546	1,087,200	54,286
1906	—	—	470,200	7,716
1907	—	—	873,400	36,723
1908	—	—	1,881,800	63,593
1909	—	—	980,350	26,565
1910	—	—	847,200	34,754
1911	—	—	1,386,400	32,252
1912	—	—	3,296,000	61,100
1913	—	—	2,088,400	51,252
1914	—	—	2,086,200	43,852
1916	—	—	667,400	14,398
1919	414,455	28,393	—	—
1928	110,149	7,755	—	—
1929	36,123	3,190	—	—
1930	88,635	1,801	—	—
1931	157,763	3,592	—	—
1932	107,891	1,699	—	—
1933	178,901	1,834	—	—
1935	13,000	753	—	—
1937	9,300	378	—	—
1939	8,500	192	9,266	493
1940	64,740	702	32,164	396
1941	47,800	1,543	47,800	1,543
1942	160,800	3,388	160,374	3,258
1943	272,400	8,099	360,923	10,930
1944	—	—	452,549	22,627
1945	14,700	794	637,620	32,901
1946	1,084,700	38,237	1,091,543	38,566
1947	304,395	6,223	1/	
1948	2,552	86		
1949	4,908	206		

* Number of fish.

1/Beginning in July, 1946, the U. S. Fish and Wildlife Service and the Maine Department of Sea and Shore Fisheries started collecting statistics cooperatively and publishing them as one report.

Sources: Reports of the U. S. Commissioner of Fish and Fisheries; Fisheries Industries of the U. S., and Reports of the Commissioner of Sea and Shore Fisheries (Maine).

Table 2.—Statistics of Shad Landings for the Kennebec River by Counties, 1896-1937.

Year	Lincoln County		Sagadahoc and Kennebec Counties		Totals	
	Pounds	Value	Pounds	Value	Pounds	Value
1896	—	—	—	—	870,366	$26,257 1/
1898	394,000	$7,880	624,000	$12,480	1,018,000	20,360
1900	117,400	4,324	642,200	16,199	759,600	20,523
1902	163,500	5,163	516,250	17,127	679,750	22,290 1/
1903	269,000	7,210	759,600	25,820	1,028,600	33,030
1904	240,000	7,850	662,200	29,799	902,200	37,649
1905	246,200	12,225	592,600	35,556	838,800	47,781
1906	135,200	1,594	187,600	1,876	322,800	3,370
1907	209,400	9,570	134,400	11,768	343,800	21,338
1908	226,400	11,326	221,200	9,954	447,600	21,280
1909	294,600	13,701	348,400	3,048	643,000	16,749
1910	103,000	6,308	269,400	16,191	372,400	22,499
1911	87,400	4,682	388,000	13,580	475,400	18,262
1912	107,000	5,175	525,000	26,250	632,000	31,425
1913	372,200	9,807	571,000	12,865	943,200	22,672
1914	555,400	20,116	718,000	7,580	1,273,400	27,696
1919	139,384	11,174	46,330	7,695	185,714	18,869 1/
1928	39,385	5,623	—	—	39,385	5,623 1/
1929	10,260	1,066	—	—	10,260	1,066 1/
1930	7,900	459	—	—	7,900	459 1/
1932	69,102	1,398	2,394	65	71,496	1,463 1/
1933	137,780	1,155	1,449	9	139,229	1,164 1/
1935	1,500	158	800	30	2,300	188 1/
1937	1,000	112	—	—	1,000	112 1/

1/ Federal statistic. All others are taken from the Reports of the Commissioner of Sea and Shore Fisheries for the State of Maine.

The sudden decline in catch in 1906 (Table 2, Fig 2) led to the following official comments:

> "This is a variety of fish which was once very plentiful in practically every river of this State, but has been gradually diminishing in numbers until at the present time the catch is very small. I think it may be correctly assumed that the decrease in the shad fishery is in large measure due to the same causes that have so injured the alewife and salmon fishery; viz., pollution of rivers and failure to provide proper fishways in dams. The Kennebec River in past years was noted for the quantity and especially the quality of the shad caught within its waters, but there remains of this great fishery only a remnant of its former greatness." (Report of the Commissioner of Sea and Shore Fisheries of the State of Maine, 1907-1908).

After 1906, the catch in the Kennebec improved somewhat. It was believed at the time that the presence of large schools of shad off-shore indicated both the possibility that river conditions were unsuitable for their entrance and a future return in abundance:

> "This year large schools of shad have been found from 10 to 20 miles off our coast, and many large catches have been made by seiners. This may indicate a return of the fish which furnished another reason why suitable provision should be made to allow them to reach their natural spawning grounds (Ibid., 1907-1908, p. 23).

> "These fish were once very plentiful in the rivers of this state especially the Kennebec, but in recent years the catch has been gradually decreasing, so that it has now become very small, although the catch on the Kennebec and its vicinity this year has been larger than formerly. Two years ago very large shad were found along the coast, but contrary to their usual habits they staid outside in the outer by and beyond the outside islands, and did not come into the rivers . . . There have been, however, large quantities of small shad caught in the weirs this year, which may indicate that we will have a return of the large ones another season." (Ibid., 1909-1910, p. 20)

The possibility that the off-shore schools were not Maine fish was overlooked, since it is only within recent years that it has been shown that shad spawning in more southern waters may later migrate to the coastal waters of Maine.

By 1912, the catch in the Kennebec had attained earlier levels but the increase was temporary (Table 2). The shad catch had become so small by 1918 that

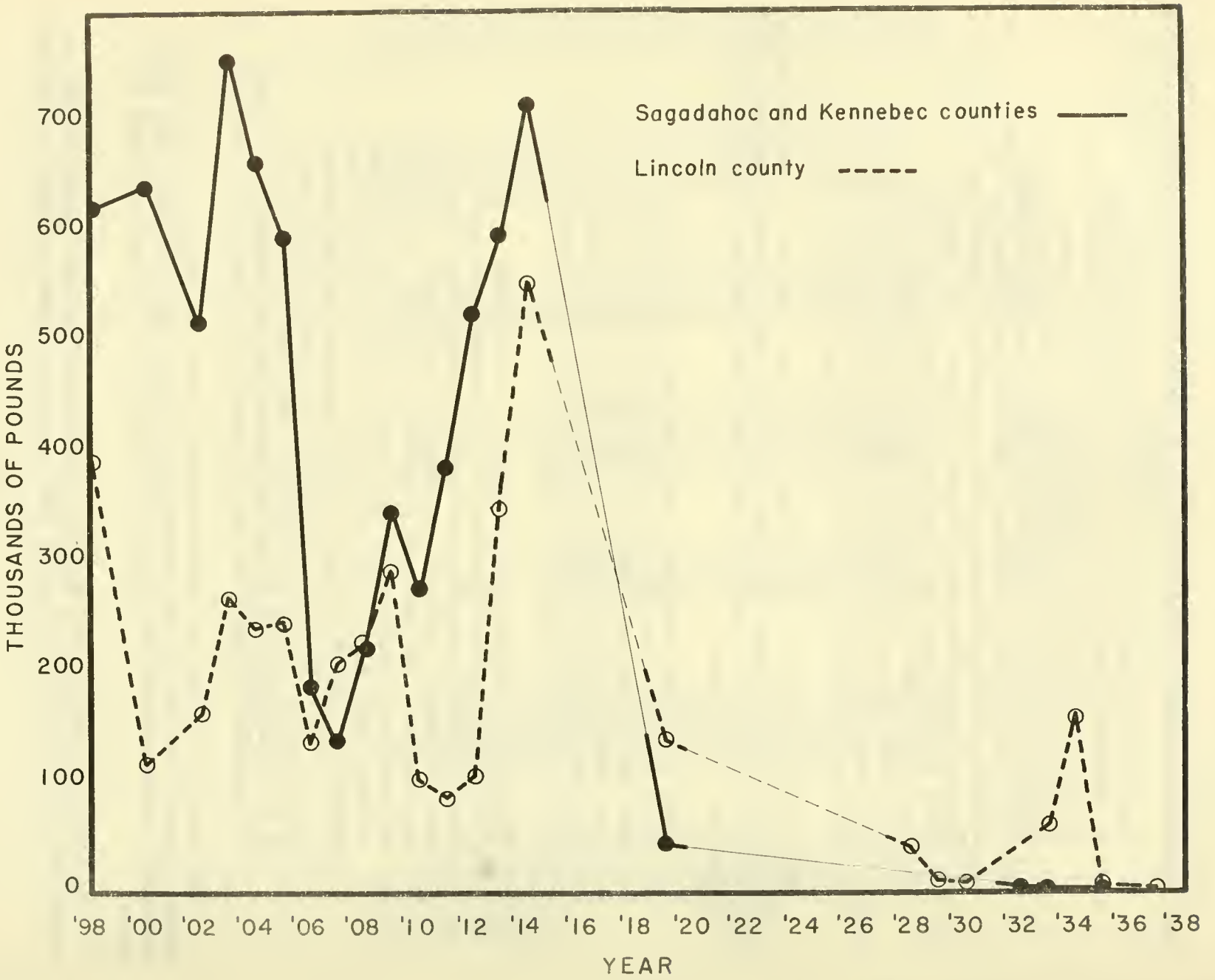

Figure 2. -- Comparison of the annual catch of shad in Sagadahoc and Kennebec Counties with the catch of Lincoln County.

the species was no longer mentioned in the Reports of the Commissioner of Sea and Shore Fisheries.

Clues to the causes of the abrupt decline in the shad catch in the lower Kennebec are few. Surprisingly, there is very little comment or speculation in the official records as to the cause of the decline.

The fortunate circumstance that shad landings in the Kennebec were frequently reported by counties, both in Federal and State statistics of landings, makes it possible to isolate, to a degree, the possible factors which were causing the decline. From Augusta to the sea, there are three counties bordering the Kennebec: Kennebec County, Sagadahoc County, and Lincoln County. Kennebec County includes the upper portion of the river below Augusta. The fishery for shad in Kennebec County was practically nonexistent by the time statistics of landings began to be collected with regularity. The reports of the Commissioner of Sea and Shore Fisheries do not show any landings for Kennebec County ever the period for which shad landings are reported. The Federal reports, however, show landings for Kennebec County for the years 1902, 1905, and 1919. It is probable that the small landings for Kennebec county were included with Sagadahoc County in the State statistics and, possibly, in some of the Federal statistics. In Table 2, landings of Kennebec County are included with Sagadahoc County whenver they are shown separately.

Lincoln County landings of shad consist entirely of landings from one source; the Eastern river (a tributary of the Kennebec). It is thus possible to distinguish the catch of the Eastern river from the rest of the Kennebec because of its isolation from the rest of the Merrymeeting Bay district and because it lies entirely within Lincoln County. Since there are no towns on the Lincoln County side of the Kennebec where shad could have been landed and credited to Lincoln County, the Lincoln County landings reported in both the Federal and State statistics may be considered to represent entirely the catch from the Eastern River. There is, of course, some possibility that a part of the Eastern river catch may have been landed in and credited to Sagadahoc County.

Landings from Sagadahoc County, on the other hand, include landings from the Androscoggin, the Cathance, the Abagadasset, and Merrymeeting Bay proper, as well as the small catches from Kennebec County. The point of importance is, however, that these landings represent a unity of conditions - the conditions of the Merrymeeting Bay district including the influence of the Androscoggin on the bay. The Eastern river, because of its isolation from these conditions, was not so directly influenced by them, especially as concerns the pollution from the Androscoggin.

The above argument is validated to a degree by the pattern of fluctuations of catch in the Kennebec proper (Sagadahoc and Kennebec counties) and in the Eastern river (Lincoln County), as is shown in Table 2 and Figure 1.

The Lincoln County catch fluctuates in a general way with that of the main river as indicated by the Sagadahoc-Kennebec county landings which, in turn, represents largely the catch from Merrymeeting Bay itself ($r = 0.484$, df 15, P (5%) = 0.482). There is sufficient deviation in the pattern of fluctuations, however, to conclude that the Eastern river represents a set of conditions unlike that of the Merrymeeting Bay district. These conditions might be of several kinds, such as independent runs of fish, natural environmental conditions, or artificial environmental conditions varying from the main river.

A tremendous reduction in the catch occurred in 1906. Table 2 and Figure 1 show that the decrease in the Eastern river was proportionately smaller than in the main river (i.e., the Merrymeeting Baby district). In 1907, the catch in the Eastern river was back to a normal level while that in the main river continued to decline. By 1914, the catch in both the Eastern river and in Merrymeeting Bay had regained former levels.

A former shad fisherman stated that 1918 was the last good shad year in Merrymeeting Bay, after which there were no shad at all (p. 10). There are no statistics of landings for 1918, but those for 1919 bear out his statement. The Sagadahoc County landings show only 46,330 pounds of shad for an area which normally produced 500,000 pounds or more annually. The Lincoln County landings (Eastern river) for the same year, while low, are not outside the range of earlier variations in catch.

Following 1919, statistical information is fragmentary. The occasional reports show that the shad fishery had become of negligible importance. One is unable to account for the Lincoln County landings of 138,000 pounds for 1933, or those for later years. Interviews with fishermen in the Merrymeeting Bay area have not revealed any information of fishing activity in the area for the years these catches are shown.

The statistics of landings in Sagadahoc and Lincoln Counties lead one to conclude that detrimental conditions existed in the Kennebec River and especially in Merrymeeting Bay which did not immediately affect the Eastern River because this river was isolated from these conditions. While at the present time it is impossible to state exactly what these conditions were, it appears probably that pollution of various kinds was affecting the survival of shad in the Merrymeeting Bay area.

In Merrymeeting Bay, including the Cathance and the Abagadasset rivers, the area is subject to the direct influence of the Androscoggin river which is known to be heavily polluted. The fishery in the Androscoggin below Brunswick had disappeared by 1884: "Poisonous matter from the Brunswick factories destroyed the spawning grounds of the shad and drove them away." (Report of the Commissioners of Fish and Game of the State of Maine for the year 1884, p. 10).

Sawdust from mills at Augusta undoubtedly contributed to the destruction of spawning grounds in the river and may have been a principal factor in the disappearance of shad in the Augusta area at an early date, as well as in the

Merrymeeting Bay area at a later date. Stevenson (1898, p. 265) states:

> "The greatest injury to shad in the Kennebec has been the vast quantities of sawdust run into the river from numerous sawmills, covering the river bottom in many places, so that areas formerly eligible for spawning grounds are no longer suitable. The fishermen state that this refuse is so abundant in Merrymeeting Bay that at times the bottom of the weirs are covered several feet therewith."

At the present time, there is no evidence of sawdust pollution in the Kennebec. There is no longer any extensive sawmill activity at or below Augusta and, so far as is known, no mill is dumping sawdust into the river at present. Sawdust pollution may be considered a factor which no longer exists in the Kennebec.

During the latter part of August and through September, 1950, no evidence of industrial pollution was apparent in the tributaries of Merrymeeting Bay which were examined. At South Gardiner on the Kennebec proper, a very thin oil layer was observed and Mr. Moulton, a local sucker fisherman, complained that oil pollution at this point was frequently very noticeable. He stated that it came from oil tankers discharging their cargoes at Gardiner. No reports of oil pollution were heard in the Merrymeeting Bay area, so that apparently this oil pollution becomes dissipated before reaching the bay. The fishermen interviewed in the Merrymeeting Bay area consider the Kennebec suitable for shad as far as pollution is concerned.

Mr. Mayers, a resident of the Eastern river area, considered the conditions in that river to be not noticeably different from those conditions when shad were abundant. The fact that this river has maintained an alewife run and is frequented by sturgeon and smelts indicates it to be comparatively less polluted than other streams of the Kennebec system.

The lower Cathance river was reported by Richard Dunham, Bowdoinham, to be polluted by the Androscoggin. A heavy winter mortality of eels in 1947 was reported by Mr. Dunham and he blamed it on pollution from that river carried into the Cathance by tidal action.

Conclusions

The disappearance of shad from the rivers and streams of Maine was almost entirely a result of their exclusion from spawning areas by dam construction. The major exception to this was the lower Kennebec river where a shad fishery existed for many years following the closing of the river at Augusta in 1837. The eventual disappearance of shad below Augusta is believed to have been caused by industrial pollution. This pollution appears to have been principally sawdust pollution, resulting first in wiping out the fishery just below Augusta and eventually extending to the Merrymeeting Bay area, the principal shad-producing district of the river. Industrial pollution from the Androscoggin, coming from textile and paper mills, has an extensive influence

in Merrymeeting Bay and possibly is carried up the Kennebec by tidal action as far as Richmond. This pollution appears to have destroyed the fishery in the lower Androscoggin below Brunswick as early as 1884. While probably an important factor in the decreases occurring in Merrymeeting Bay about 1906, no direct evidence supporting this conclusion is available.

The Eastern river, presumably because of its relative isolation from the direct influence of the Kennebec and the Androscoggin, maintained normal catches of shad for a period of years after the fishery in Merrymeeting Bay had all but ceased to exist.

Two rivers, the Nonesuch and the Sheepscot, have small runs of shad at the present time. The Nonesuch run appears to be stabilized. The run might possibly be improved through deepening the channel at some points to allow free access to upper pools where the gravel and sand bottom is favorable for spawning. As for the Sheepscot, the opening of the dam at Headtide should make it possible for the shad to recover naturally in this river. Steps to guarantee that the passages through the dam are kept free of debris at all times are recommended.

Three rivers with former shad runs appear suitable for stocking, when and if such a measure is contemplated. They are, in the order of their suitability, the Eastern, the Cathance, and the Abagadasset. The Abagadasset is considered the least suitable because of the small volume of fresh water entering its tidal portion, because it does not offer much sand bottom, and because it is subject to possible tidal inflow of pollution coming from the Androscoggin. The Cathance river, in its upper part is probably free from the influence of the Androscoggin and has a good proportion of sand and gravel bottom. The inflow of water from its drainage area is about equal to that of the Eastern river.

The Eastern river not only has a greater area of sand and gravel bottom than the Cathance but is probably beyond the influence of water from the Androscoggin. The presence of alewives, smelt, and sturgeon indicate it to be relatively free from serious pollution from the Kennebec.

The remaining coastal rivers of the State are, for the most part, unsuitable for shad because they are dammed near their mouths, making spawning areas inaccessible. The few which remain unobstructed have, with one or two exceptions, no history of a shad run and therefore may be presumed to have natural conditions unsuitable for shad.

Table 3.—Shad Streams of Maine.

Rivers	1950 Catch* No of Fish	Miles Available Stream	Limiting Obstructions* Dams	Falls	Pollution*
Mousan River	0	3½	X	-	D
Saco River	0	3	-	X	I
Nonesuch River	200-400	21	-	X	-
Presumpscot River	0	4½	X	-	I
Stroudwater River	0	0	X	-	-
Royal River	0	¼	X	X	-
Kennebec River	0	25	X	-	-
Merrymeeting Bay					
Androscoggin River	0	5	X	X	D,I
Cathance River	R	5½	-	-	-
Abagadasset River	0	4	-	-	-
Eastern River	R	8	-	-	-
Sheepscot River	13	14⅕	XF	-	-
Dyer River	0	4	X	-	-
Damariscotta River	0	0	-	X	-
Georges River	0	0	X	-	-
Oyster River	0	0	-	X	-
Ducktrap River	0	2	-	X	-
Passagawaukeag River	0	0	X	-	-
Penobscot River	0	0	XF	-	I
Narraguagas River	0	45	-	-	-
Pleasant River	0	0	X	-	-
Harrington River	0	0	-	X	-
Chandler River	0	5	-	-	-
Machias River	0	0	-	XF	-
East Machias River	0	⅕	XF	-	-
Dennys River	0	11⅕	X	-	-
St. Croix River	0	0	X	-	I

*Symbols used:-R indicates few shad taken within past 10 years and believed still present by local fishermen; X denotes type of obstruction present; XF shows that the obstruction has a fishway but no evidence of its use by shad; D or I denotes Domestic or Industrial pollution.

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