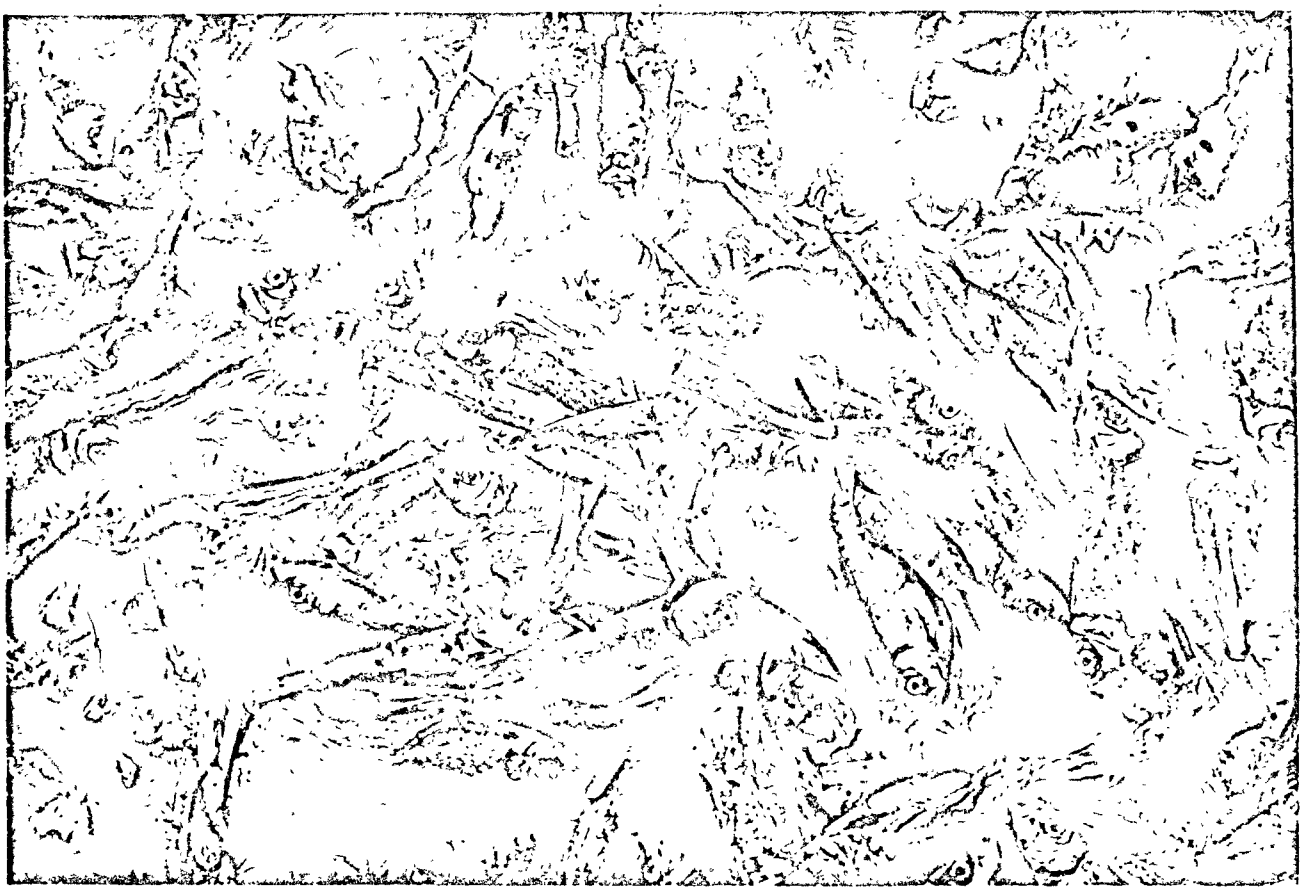
THE ALEWIFE EXPLOSION

The 1967 Die-Off in Lake Michigan



A Report by the Federal Water Pollution Control Administration
Great Lakes Region

July 25, 1967

ENVIRONMENTAL PROTECTION AGENCY

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NOT FOR PUBLICATION

INTRODUCTION

On June 15, while on a flight to investigate sources of pollution in Lake Michigan, an official of the Great Lakes Region of the Federal Water Pollution Control Administration spotted long white streaks in the water. The Navy Hydroplane in which he was riding dipped lower. The streaks were windrows of dead alewives, belly-up. The wind was blowing the dead and dying fish toward the Michigan side of the lake. The official observed one great shimmering band of alewives stretching for 40 miles between Muskegon and South Haven, Michigan. On June 17, an article in the Chicago Sun-Times mentioned the dead fish and how they had become an annual pollution problem by littering beaches and producing a noxious stench. Over the weekend, June 17-18, however, the wind shifted, blowing from east to west. By Monday, June 19, Chicago's 30 miles of shoreline was clogged with a silvery carpet of alewive carcasses. The following day, Tuesday, June 20, the dead fish continued to pile up in incredible numbers. The great alewife invasion of 1967 was on. Previous die-offs pale in comparison. None of the Great Lakes had ever experienced fish deaths of such a continuing magnitude before. Newspapers, which previously had devoted only a few paragraphs to the annual event, now had comprehensive front-page stories. (See Appendix)

Theories as to what caused the massive kill proliferated, as the fish stacked up on beaches in Michigan, Indiana, Illinois and parts of Wisconsin, posing a giant and unprecedented disposal problem.

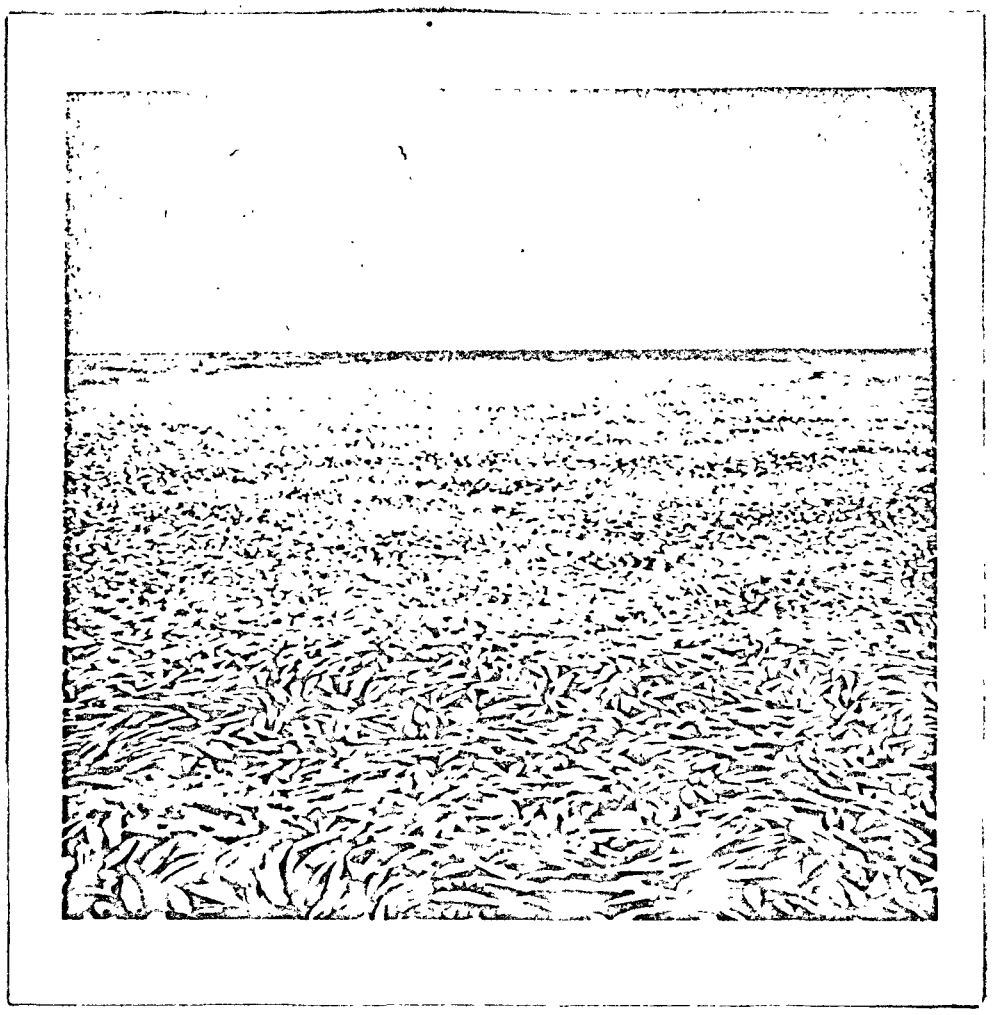
The FWPCA, Great Lakes Region, had investigators conduct a special water quality survey, sampling the waters in the southern basin of the lake from Milwaukee, Wisconsin, to Grand Haven, Michigan. Tests were conducted

to determine the chemical, biological and bacteriological content of the waters; fish carcasses were examined for pesticides; a certain algae which some scientists believe is toxic was also studied. All the evidence assembled indicates that water pollution is not responsible for the alewife deaths.

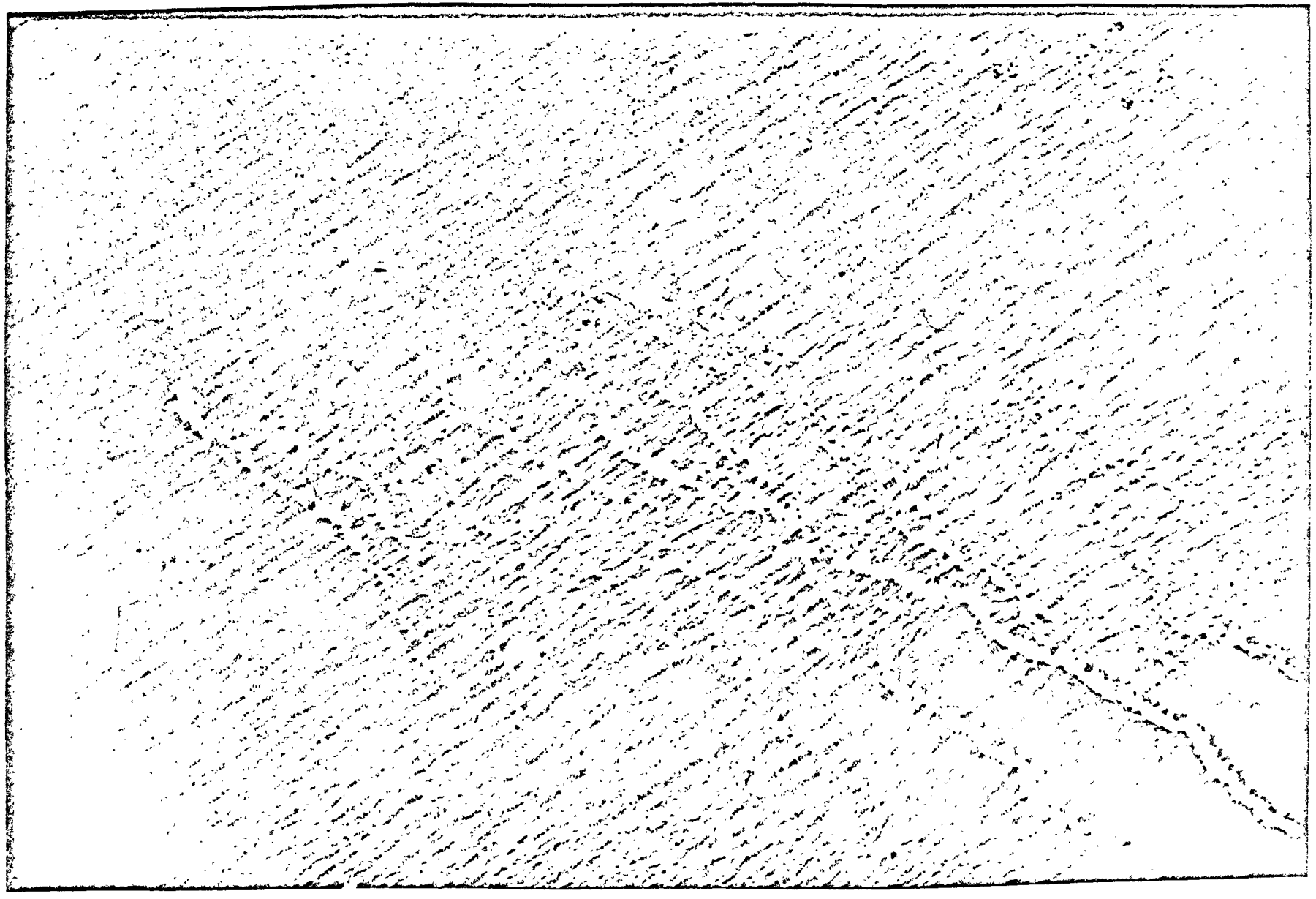
However, it is also obvious that the balance of nature in the lake waters had precariously tilted. With the disappearance of natural predators, the alewife population had exploded.

If natural checks are to be restored by the stocking of such game fish as lake trout and coho salmon, it will also be necessary to make sure that the waters of Lake Michigan are further protected from contaminants, for game fish are some of the first victims of pollution, as Lake Erie has so harshly demonstrated.

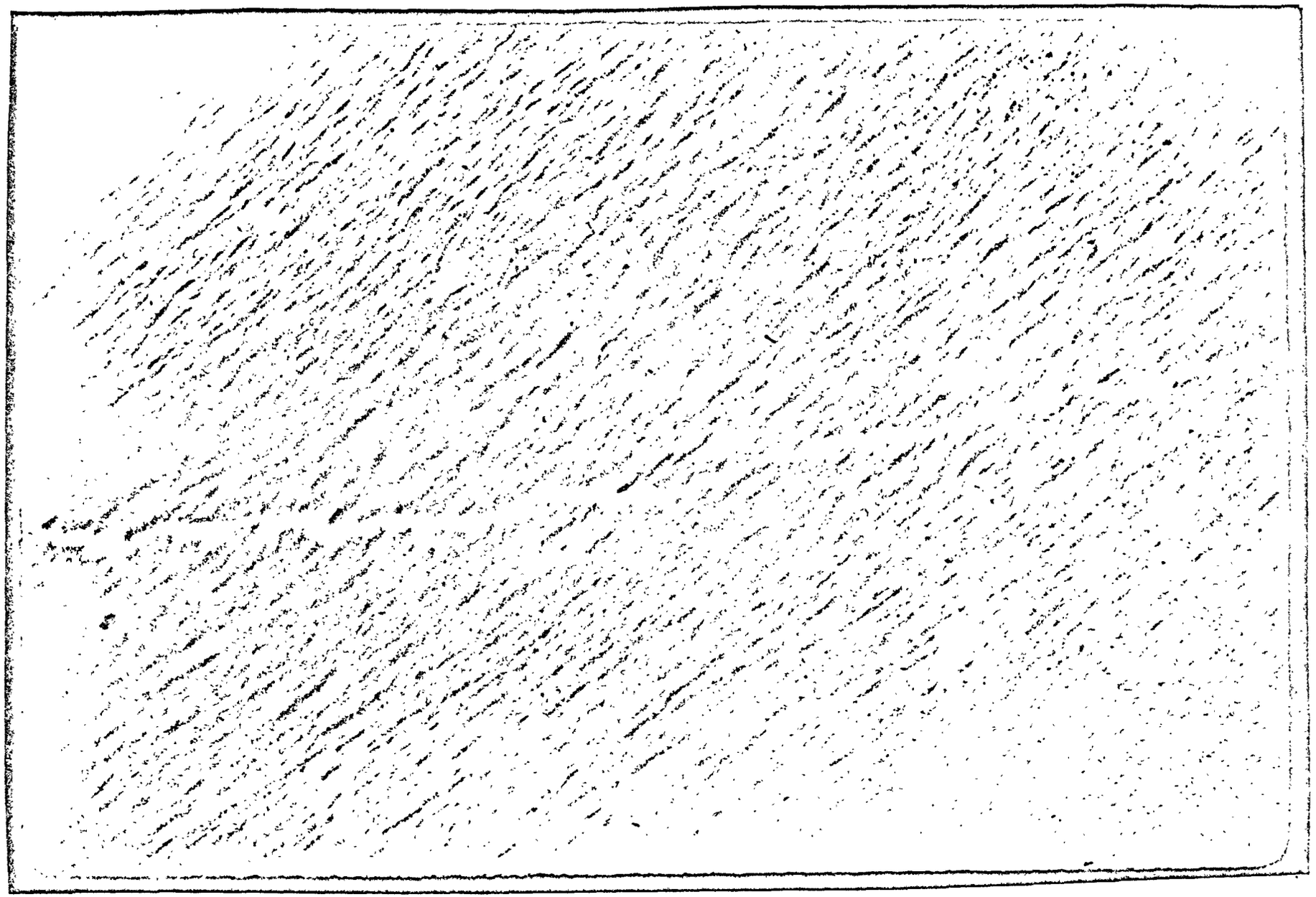
This paper, besides reporting on the water sampling program conducted by the FWPCA, has also compiled a variety of literature on alewives. From an examination of this literature, some conclusions have been drawn which may prove helpful in dealing with this environmental disaster.



A giant windrow of dead alewives is shown here in the middle of Lake Michigan. Some of these windrows extended for 40 miles and were 50 feet in width.



Dead alewives leave the surface of Lake Michigan streaked white. These fish were photographed from an altitude of 500 feet north of Benton Harbor, Michigan. 6-15-67



Another view of a windrow of alewives being blown toward the Michigan shore. 6-15-67

SPECIAL WATER QUALITY SURVEY

The FWPCA's Chicago Program Office, Great Lakes Region, conducted a special water quality sampling survey on June 30, July 1, and July 2, following the shore line around the lake from Milwaukee, Wisconsin, to Grand Haven, Michigan.

The water's chemical, biological and bacteriological contents were examined. Chemical tests of such pollutants as ammonia nitrogen, sulfates, chloride, phenol, cyanide, and other contaminants did not show any unusual levels which could be linked with the fish die-off.

Both the waters and the fish were checked for pesticides. Water samples were relatively free of pesticide residues, but the bodies of the fish did contain fairly large amounts of the contaminant. However, healthy alewives have been reported to contain levels in excess of those found in the examination, and lethal doses of pesticides were not discovered, leading investigators to conclude that pesticides are not a significant factor in the die-off.

However, the FWPCA's Southeast Water Laboratory at Athens, Georgia, will assist the Chicago Program Office in further pesticide studies, comparing healthy and dying fish, and examining the liver, gill and brain tissue of healthy alewives.

The waters were also checked for bacterial levels and temperature. Blue green algae, which some scientists are investigating for toxicity, was also scrutinized. There were no large concentrations of these algal blooms at the time the survey was conducted, though.

In general, the findings did not indicate the presence of any extreme or bizarre pollution conditions in the waters that could have caused the massive die-off. (Details of the survey are contained in the Appendix.)

ENVIRONMENTAL ASPECTS OF THE PROBLEM

The delicate balance that was tipped and led to the alewife's population explosion cannot be blamed on any one occurrence. There are many factors that contributed to environmental changes, including: overfishing, man-made canals, water pollution. It was an already altered aquatic environment that was entered by the sea lamprey, another invader fish, which gained access in great numbers to the Great Lakes with the opening of the St. Lawrence Seaway. The lamprey is a parasitic type of fish that is often confused with an eel because of its eel-like appearance. The lamprey has a sucking disc set with variable teeth with which it attaches itself to fish and, after rasping a hole in the body, sucks nourishment from its host. The lamprey decimated what remained of Lake Michigan's lake trout population, which had kept the alewives in check. The lampreys have been brought under control by treating the headwaters where they spawn with a highly selective chemical that kills off their larvae while not harming other forms of aquatic life. The sea lamprey in its native salt water habitat reaches a length of nearly three feet, but, like the alewife, is much smaller in fresh water, averaging seventeen to eighteen inches in length. The sea lamprey had been virtually landlocked in Lake Champlain and Lake Ontario until the digging of more canals gave it access to the other Great Lakes. An example is the Welland Ship Canal which connects Lakes Ontario and Erie, where construction to replace the old canal began in 1913. The lamprey may have reached Lake Ontario by swimming up the Hudson River and on through the New York Barge Canal to the lake, a route the alewife is also thought to have favored.

With the lamprey under control, restocking of Lake Michigan with lake

Flies, such as the ones spotting the carcasses above, came in swarms to feed on the dead alewives. In addition, the decaying fish also brought an infestation of maggots (fly larva). 6-20-67

and steelhead trout and coho and chinook salmon was begun. Care must be exercised, however, if the restocking program is to succeed. Adult alewives will be available to some of these predators only intermittently because of the nature of their migrations between deep and shallow waters. The alewives live in the deepest waters in mid-winter, move along the bottom through the intermediate depths in late winter and early spring, and inhabit the shallow areas near shore and in the rivers during spawning. In autumn, they migrate back to the intermediate areas. The young hatch during the summer and spent most of their first two years at mid-depths in the lake. A steady diet of alewives for game fish also has questionable value. Initial laboratory feeding tests show that lake trout fed an exclusive alewife diet for a period of six weeks became extremely low in thiamine (vitamin B_1) content.

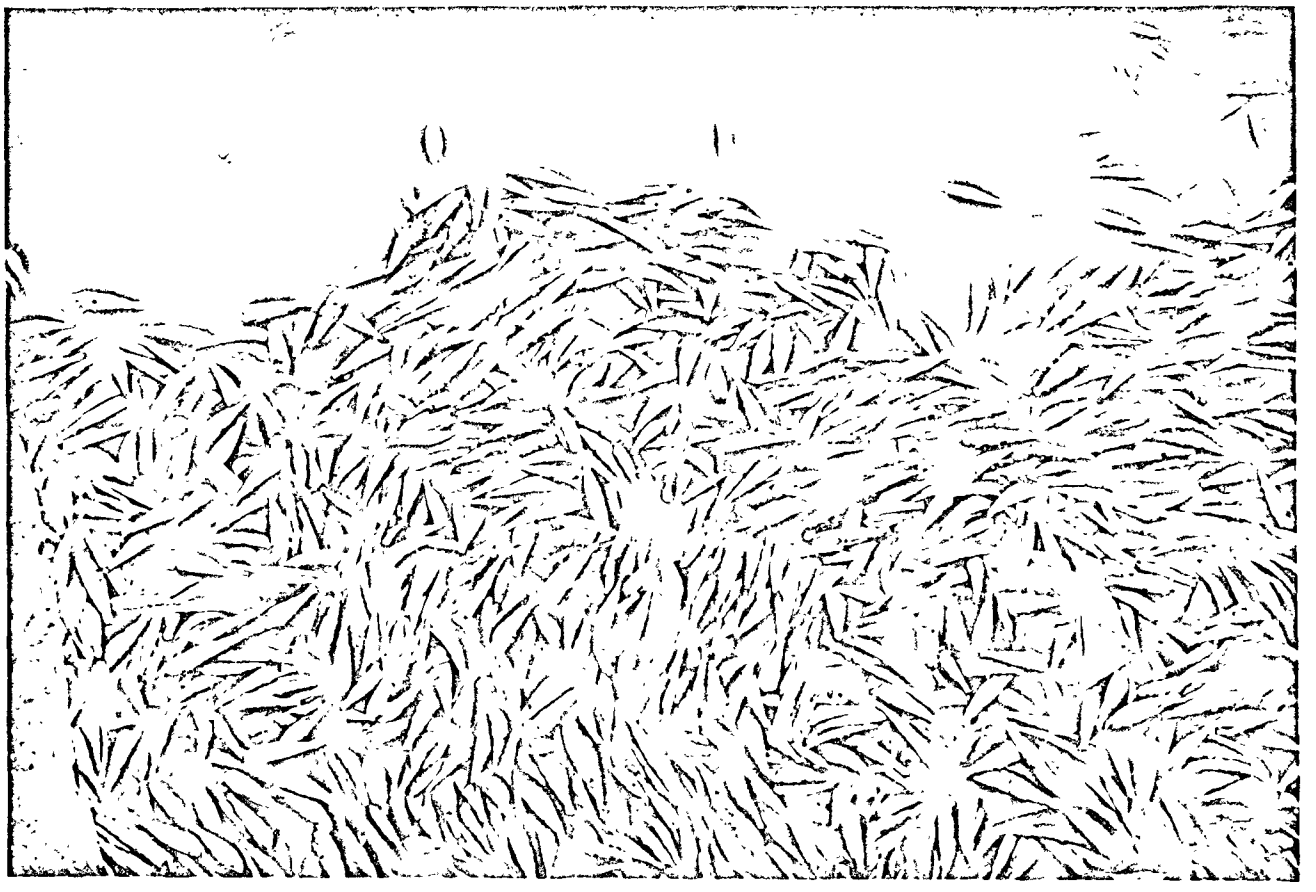
Other fish that the trout depended upon for food also declined in numbers when alewives became the dominant species of the lake. Chubs which occupied the deeper depths of the lake and smelt that lived in the intermediate and shallow areas have fallen sharply in numbers. The cisco (lake herring) and emerald shiners which lived in the shallower waters have all but disappeared; the yellow perch which resides near shore is rapidly declining. If the predator fish can reduce alewife stocks, some of the species crowded out by the alewife may come back. A controlled alewife population, however, would be desirable to serve as a form of food for the larger predators.

Such game fish as trout and salmon are also dependent on clean water. Lake Michigan's shore waters, particularly in the southern end of the lake, are becoming more "enriched" by contaminants. Pollution kills off certain

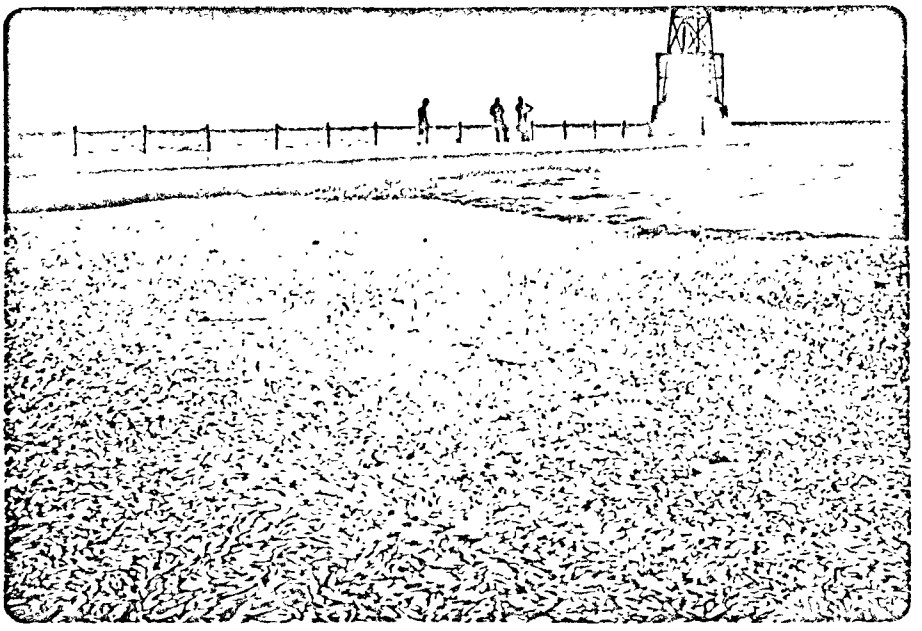
forms of organisms in the bottom muds that game fish feed on. Coarse or rough scavenger fish, such as the carp, however, can feed on other pollution-tolerant organisms, such as sludgeworms, aquatic sowbugs, bloodworms and leeches -- forms of life that indicate pollution. The carp can survive in such a despoiled environment, but the game fish cannot. They are crowded out by the coarse fish in the competition for food. Dr. Stanford H. Smith, fishery biologist for the Bureau of Commercial Fisheries, reports that carp are becoming abundant in the south end of Lake Michigan. Lake Erie is a good example of lake "enrichment," and what it does to game fish. The yellow pickerel, or walleye, and the blue pickerel have vanished, while carp and gar have established themselves in even greater abundance.

It is evident that a restocking program's success depends upon control of water pollution. A Federal enforcement conference has established water quality criteria for the south end of Lake Michigan, with timetables to meet these standards of purity. In addition, the Federal Water Pollution Control Act required all States to submit water quality standards to the Secretary of the Interior by June 30 of this year, along with plans for implementing and enforcing the standards. The Secretary will review these standards. If they are acceptable, they will become official Federal water quality standards. The strict enforcement of high water quality standards would insure an environment in which game fish could thrive and multiply.

Theories about the alewife deaths range from shock caused by temperature changes to the termination of a life cycle, from starvation and suffocation to spawning and thyroid stresses. It could well be that a combination of events is responsible, but more data and research are needed before any acceptable conclusions can be drawn.



The alewife population explosion appears to have come about with the decline of larger fish which preyed on alewives. The alewife die-off was equally explosive, as shown in the above photograph. 6-20-67



Chicago was the first community to experience the alewife invasion. Above is the scene at the Foster Avenue Beach and Breakwater where a glistening carpet of alewife carcasses has been washed ashore. 6-19-67

BACKGROUND OF THE PROBLEM

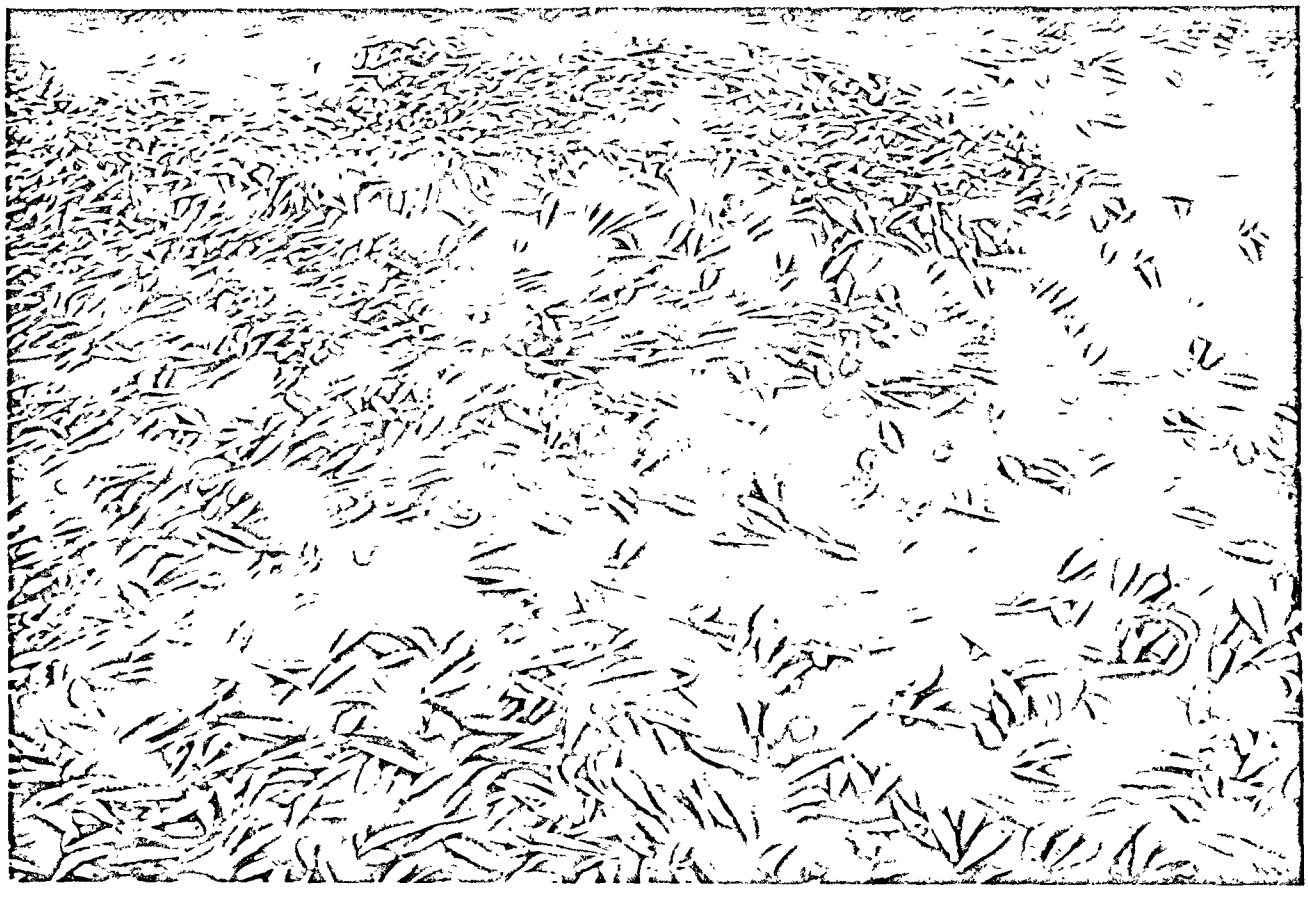
Alewife die-offs have been reported in the Atlantic Ocean since the 1700's. The alewives in the Great Lakes, unlike their salt water cousins, however, have been drawfed in their struggle to adapt to fresh water. They are about half the size of the Atlantic alewives, averaging about 6 or 7 inches compared to their Atlantic relations' 10 to 11-inch average length. Atlantic alewives also have food value, having been sought after first by Indians and the settlers of New England. The name was probably given the fish because of their puffy bellies, after the women who operated ale houses in England.

The alewife of the Great Lakes has a bigger head, enlarged by salivary glands that are overworked to maintain the same mineral (salts) balance in its blood as its ocean relative.

The Great Lakes alewife also has an atrophied (stunted) thyroid. This condition leaves it with less fat content, making it more bony, and destroying its food value, except as food for cats or minks.

Of the estimated 20 billion alewives (1) washed up dead or dying in Lake Michigan, the greatest die-off occurred in the southern basin. This is thought to be due to more extensive commercial fishing in the northern basin. There is also a market for this fish for use as fertilizer.

Alewife die-offs have become an annual event in Lake Michigan throughout the past years. Their 1967 abundance had been predicted by the Department of the Interior's Bureau of Commercial Fisheries, which noted a record hatch in 1964. The alewife habit of dying en masse when they spawn in the late spring had been observed since the 1880's in Lake Ontario.



An estimated 20 billion alewives died in Lake Michigan during June and July, rolling in wave after wave onto beaches in Chicago, Indiana, Michigan and Wisconsin. The above picture was taken at the 79th Street Beach on Chicago's south side. 6-20-67

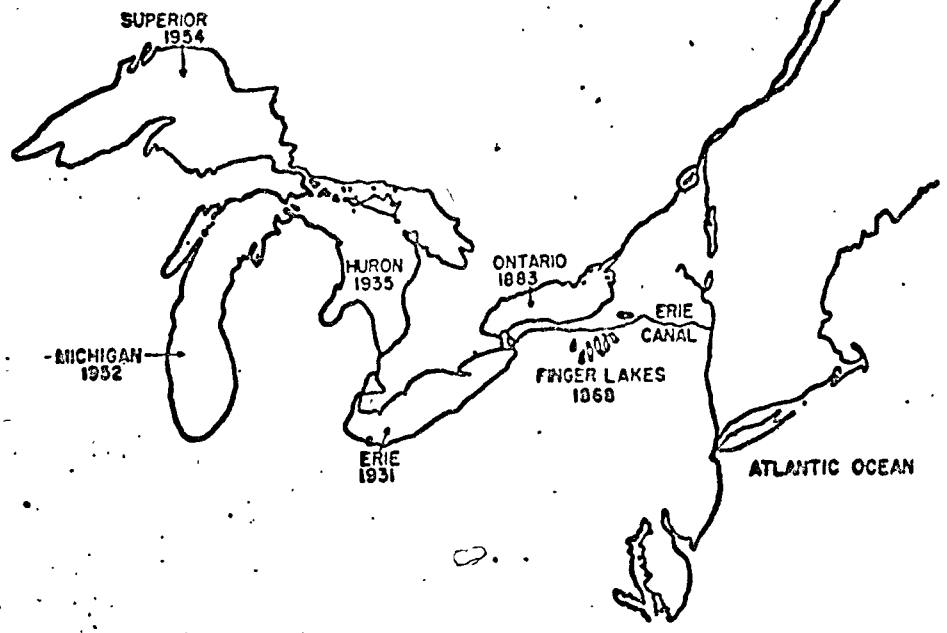
Since most alewives spawn in the third year, 1967's bumper numbers could be anticipated. (2)

Natural inhabitants of the North Atlantic, the immigrant species of the Great Lakes was first noted in the Finger Lakes of New York in 1868, with subsequent sightings in Lake Ontario in the 1880's.

The alewife has since migrated throughout the entire Great Lakes system. Figure 1, taken from Threinen's life history of the alewife (2), traces the progress of these invaders throughout the Great Lakes. Alewives soon became and continue to be the most abundant fish of Lake Ontario. They also exist in large numbers in Lake Erie, but have not become the dominant species there. However, Lakes Huron and Michigan support vast populations of this fish, and each has experienced the annual die-offs associated with spring spawning. Lake Huron preceded Lake Michigan in reaching its peak population; Lake Michigan may now have reached that stage. Whether Lake Superior will also experience explosive alewife populations remains to be seen, but progress has been made in replenishing Superior's stock of game fish which feed on alewives.

Dr. Wayne Tody (3) Chief of the Fish Division of the Michigan Department of Conservation, observed that the alewife population of Lake Michigan has increased from 17 per cent in weight of all lake fish in 1962 to 90 per cent by 1965.

The enormous numbers of alewives deposited on Lake Michigan's beaches and floating in its harbors have created massive problems for cities and towns located along it. Drinking water intakes have been plugged up; the air has become polluted with the raw aroma of rotting fish, and local capabilities and creativity have been severely strained in trying to find ways and means of disposing of the wave upon wave of carcasses that have washed ashore.



Outline map of the Atlantic coast and the Great Lakes drainage, with dates of invasion by the alewife. (Threinen)

Figure 1

ORIGIN OF THE ALEWIFE POPULATION EXPLOSION

Species Inter-Relationships in the Great Lakes

Dr. Smith, in a paper on over-exploited fishery populations in the Great Lakes, presented at a symposium in 1966 (4), lucidly described the sequence of events leading to the present over-population of the Great Lakes by alewives. Smith states that "a succession of fish species would be expected during the natural aging process of the Great Lakes, but recent progressive changes in species composition have been rapid and obviously accelerated by influences of man, both from enrichment of the environment with wastes, and dispoilment of the most abundant or preferred species of fish...leading to the state of biological instability in the mid-1960's that is almost unparalleled in fishery science." The sturgeon was largely eliminated through fishery practices. Lake herring, historically abundant, declined preciptously in the 1920's. A subsequent decline in these stocks since the mid-1940's, approaching elimination in the mid-1960's, undoubtedly is a response to an unfavorable environment. The lake whitefish were similarly reduced in numbers, due largely to the introduction of the deep trap net in 1928. Over 4.1 million pounds of whitefish were taken from Lake Huron in 1931; the catch has been less than 200,000 pounds in most years after the 1942 low. Combining with the fishery over-exploitation was the impact of the sea lamprey. The smelt, originally a native of Lake Ontario, was introduced into Lake Michigan in 1912 and underwent a population explosion in Lakes Michigan and Huron in the 1930's. This population suffered severe mortality during the winters of 1942-1943, probably due to a bacterial or virus disease.

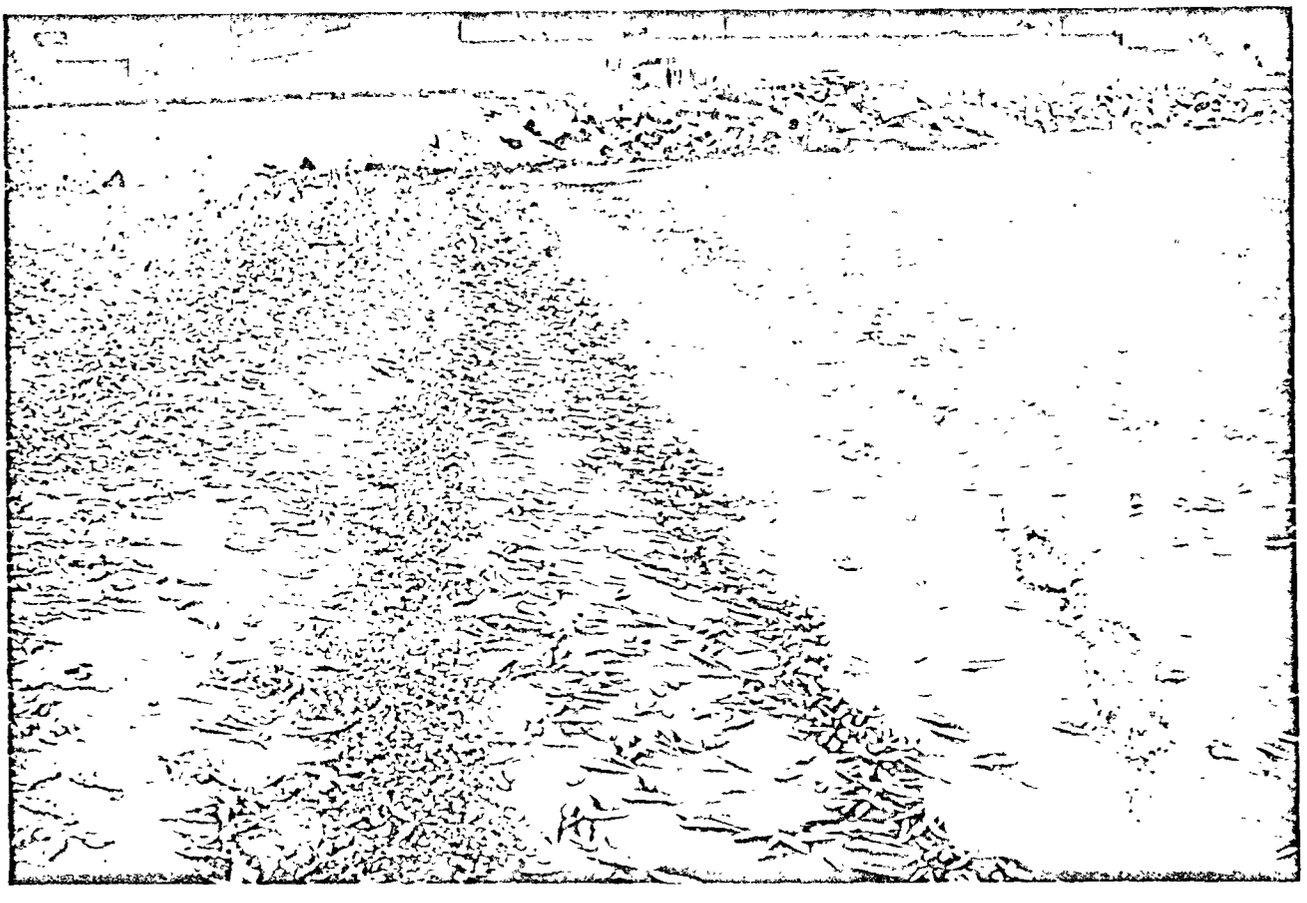
Smith generalized on the recent changes in the Great Lakes fish populations as follows:

"Until the 1940's the Great Lakes as a whole had enjoyed a stable and productive fishery despite loss of the sturgeon and the few collapses of stocks in certain lakes. All preferred species continued in abundance somewhere in the Great Lakes. Although many showed...degrees of... fluctuation, the species composition of the total catch of the Great Lakes showed no marked changes or trends....

"The major events that started in the 1940's involved the upper three lakes (Huron, Michigan, and Superior). Similar changes...apparently had taken place earlier in Lake Ontario, but...had gone almost unnoticed because the fishery was small. Changes that were progressing in Lake Erie, and which have accelerated since the 1940's, were dissimilar to those in the upper three lakes and...were related more to environmental change, but undoubtedly were also influenced by (fishing) exploitation of a few preferred species....

"The history of fishery exploitation in Lake Michigan was typical of the other Great Lakes. The highest annual production occurred near or before the turn of the century when the fishery had become well established....

"Only nine species have been major contributions to the catch and have constituted 95.6 to 99.7 per cent of the catch in periods for which records of all species are complete.



The scene of tiny white bodies invading a beach became a common sight in Wisconsin, Illinois, Indiana and Michigan. Above is the 79th Street Beach in Chicago, with the city's South District Filtration Plant in the background.

"At the turn of the century seven of these species were represented in the catch. The lake trout (Salvelinus namaycush) and lake herring were the largest contributions to the catch, and the carp (Cyprinus carpio) which was introduced into the lake in the late 1800's composed less than 1 per cent of the catch. Despite increased abundance of carp and the subsequent introduction and establishment of the smelt, the relative contribution of the native species to the catch showed no marked changes or trends until the 1945-49 period when the lake trout catch declined sharply. Subsequent species changes took place in swift succession and by 1965 the catch was dominated by the alewife (Pomolobus pseudoharengus) which invaded the lake (Michigan) where it was first recorded in 1949; exotic species constituted nearly 63 per cent of the catch, and the portion of the catch composed of lake trout, lake herring, suckers (Catostomus) and whitefish which exceeded 82 per cent in the 1898-1909 period, was only 4.5 per cent in 1965.

"Several factors contributed to this extreme change, and the interaction of these factors and the exact mechanisms that brought about the change are incompletely understood. There is no question, however, that predation of the sea lamprey triggered the decline of the lake trout in the upper three Great Lakes, and that the resultant pressures of a shifting fishery, and a population explosion of the alewife were major contributing factors....

"It is apparent that in all three of the upper Great Lakes the abundance of sea lampreys was very low at the time when lake trout stocks started to decline. There is little question that the lake trout were the prime prey of the sea lamprey and lake trout were the only abundant species of large fish that inhabited the deepwater (subthermocline) regions of the lakes.

"The small amount of exploitation by the sea lamprey that precipitated the decline of the lake trout stocks provides evidence that the commercial fishery had been operating at near the optimum rate of exploitation."

Smith concludes as follows: Following the decline of the lake trout, the chub became the last species of importance in the fishery of Lake Michigan. The consequence of the pressure of commercial exploitation and the preying of the sea lamprey, combined with the alewife out-competing them resulted in the sharp decline of the chub population. This competitive advantage of the alewife undoubtedly speeded a population explosion of alewives in Lake Michigan that gained its greatest impetus in the 1960's.

To summarize, Lake Michigan was left with a fish population consisting largely of one species, the alewives. The natural enemies of the alewives, the predatory fish species, could no longer assert a controlling effect in maintaining a balanced fish population.

Physical Description of Alewives

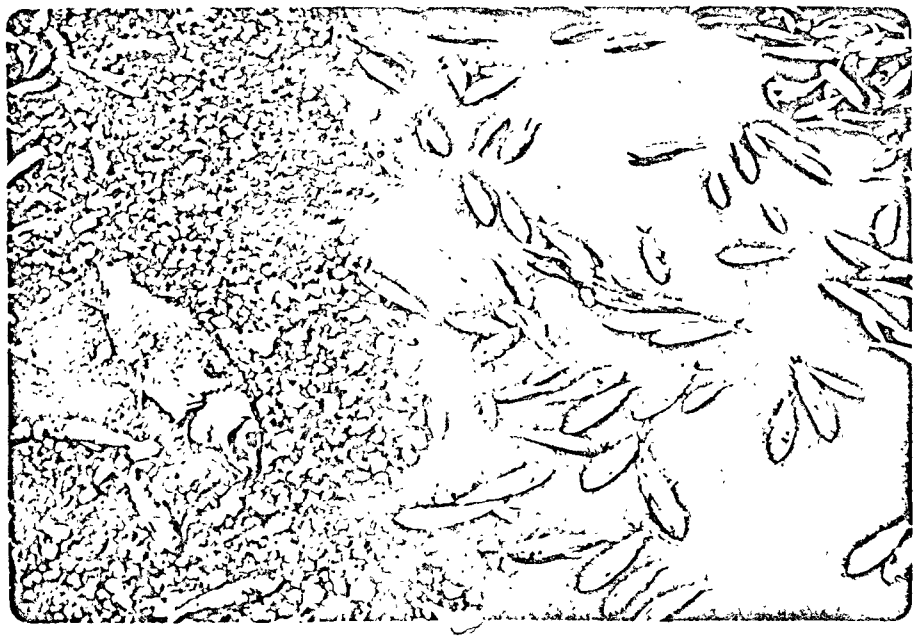
Threinen (2) describes the alewife as follows:

"The alewife like other herring has soft fins, lacks teeth, has no adipose fin, and has a forked tail. This species is characterized by a knife-edge belly and a saw-like arrangement of scales on the edge, hence the name sawbelly. This herring can be distinguished from its near relatives by its relatively heavy build forward, thin body, its big eyes and a short upper jaw and projecting lower jaw. The body is about $3\frac{1}{2}$ times as long as it is deep. Color of the back is a grey-green or brownish green which becomes a bright silvery color on the sides and belly. The cheek is also silvery. The larvae are transparent, have large eyes, and black pigment cells along the ventral portion of body."

Reproduction

When making its home in the waters of the North Atlantic, the alewife, like the salmon, goes up fresh water streams to spawn. In the Great Lakes, the spawning and egg laying usually occurs in the shallow shore waters of the lakes. In Lake Michigan, this spawning generally occurs between April 15 and July 1. Female alewives in fresh water have been observed to contain 10,000 to 12,000 eggs, according to Threinen (2), and the more prolific salt water species deposits 60,000 to 100,000 eggs. Threinen (2) also observes that the salt water dwelling adults return to salt water soon after spawning and the young migrate to salt water throughout the latter part of the summer when they are two to four inches long. In the fresh water, the young remain around the spawning grounds until the late larval stage is reached.

Laboratory eggs kept at 56 to 60° F in running water hatched in 81 to 102 hours.



Alewives in the Great Lakes have been dwarfed in their struggle to adapt to fresh water, averaging only six to seven inches compared to the average 11-inch length of their Atlantic cousins. Their size is shown here in relation to the dead carp in the left of the picture. 6-20-67

Habits and Habitat

Threinen (2) describes the habits and habitat of alewives as follows:

"Alewives are . . . a . . . gregarious fish (they flock together). In the ocean, schools as large as 40,000 fish have been observed. In Lake Michigan schools of spawning fish were thought to number 5,000 to 6,000 individuals in schools 15 to 20 feet in diameter. While on the inshore migration they come into shallow water at night and remain off-shore during the day. In late August they migrate to deep water. Test netting in the Finger Lakes yielded alewives at all depths down to 160 feet. Test netting in Lake Ontario revealed that alewives were most abundant between 30 (180 feet) to 50 (300 feet) fathoms. Following spawning, some mortality of adults has been observed among the ocean migrants. Lake Ontario populations have been periodically subjected to large summer die-offs when the adults enter shallow water. This phenomenon has been correlated with water temperature changes, the alewife being unable to adjust to the 10° C. (50° F.) temperature gradient between deep and shoal water. The alewife is characterized as being unable to adjust to rapidly rising or fluctuating temperatures. It is also a fragile fish which will not stand much handling."

Food Habits

The main staple of the alewife diet is animal planktonic organisms. In a study made on Seneca Lake, New York, alewives showed that 46% of the volume of stomach contents were microcrustacea. Threinen (2) also observes that in this New York study 24 specimens captured in Lake Ontario had eaten mostly Mysis relicta, an opossum shrimp inhabiting deep water, and some Pontoporeia, a deep water scud. It was concluded that alewives rarely take

fish, eat chiefly animal plankton, and take other food if available. Salt water alewives cease feeding when they go up fresh water streams to spawn.

Growth

The Great Lakes alewives do not reach a size comparable to those occurring in the North Atlantic Ocean. The ocean alewives attain a length of 15 inches, with the average size being 10 to 11 inches and 8 to 9 ounces. The average length of the fresh water alewife is about 6 inches. Threinen (2) observes that apparently few Atlantic alewives live beyond 5 or 6 years.

Economic Value

The alewives from the Great Lakes to date have had low commercial value. Most of the catch is used for animal food or fertilizer. Threinen (2) states that some of the salt water catch is salted, smoked, or pickled like other species of herring. However, the thin body and many small bones detract from its value. Much of the Wisconsin production becomes mink food. Eastern fish hatcheries have used alewives as trout food.

THEORIES ON THE ALEWIFE DIE-OFF

There has been much speculation as to what causes the annual alewife die-off. Theories include starvation; temperature shock during the migration from cold deep waters to shallow spawning waters; natural death at the end of a three-year cycle; toxic algal blooms; oxygen depletion in spawning waters; disease; spawning stress; extreme sensitivity of the alewife, and an osmotic stress associated with the alewife's struggle to make the adjustment from salt to fresh water.

Preliminary data compiled by the Bureau of Commercial Fisheries has established that the number of yearlings among the dead is greater than in previous years. Twenty per cent of a random sample taken from a half-mile of beach south of Saugatuck, Michigan, were yearlings. Based on data from samples being examined in laboratories, yearlings account for 28 per cent of the total.

There is also a scarcity of two-year-old fish, the bureau reports. This age group occupies midwater levels and is not caught in bottom trawls. The two-year-olds begin to join the adult stocks on the lake bottom in July. By November, almost all have migrated to the lake bottoms.

Both sexes are represented among the dead fish, the bureau adds. Most of the adult females examined had not spawned, so the die-off is not being associated at this point with a post-spawning mortality. There is also little indication of emaciation. Approximately one-half of the dead alewives examined had some food in their stomachs.

There was also a significant die-off during the winter. Bottom trawling in April by the R/V Cisco produced far greater numbers of dead and partially decomposed alewives than had been observed in previous years.

Ten days after they were washed ashore, the alewives had decomposed to the extent shown above on a Chicago beach. The bones of decomposed alewives can be a hazard to the feet of bathers. 6-30-67

The Bureau of Commercial Fisheries is pursuing an investigation into the role played by temperature and thyroid exhaustion as a possible cause of die-off.

Although all the functions of the thyroid are not understood for fish, it has been suggested that it is related to growth, osmotic regulation, and temperature tolerance. Alewives are subjected to sharp temperature changes as they move shoreward in the spring and early summer. Thyroid exhaustion also provides a possible theory for the mid-winter mortality since it is believed that the thyroid hormone produces resistance to low temperatures (5).

The alewife is subjected to extreme temperature fluctuation when it migrates from the cold (9 degrees centigrade) deep waters of the lake to the warmer (19-20° C) shoal areas and tributaries to spawn. Laboratory studies have shown such fluctuations to cause fish deaths (6). Field observations by Dr. Smith and other Bureau of Commercial Fisheries personnel have substantiated the laboratory findings. Although a disease factor could be present, no evidence is available to support this thesis at present.

The association of springtime "blooms" of certain toxic plankton with alewife mortalities has been mentioned by Woods (7) and Williams (8). Woods, however, states that this theory has not been demonstrated.

The theory that alewives spawn in shallow sluggish waters in such numbers that they exhaust the existing oxygen supply and suffocate was dismissed after oxygen tests were run (9).

McKim (10) stated that the temperature fluctuation thesis might best explain the larger numbers of young fish dying this year. The rise in alewife population, followed by mass mortality, has occurred as the population moved each year up through Lake Huron and down through Lake Michigan. If

Lake Michigan behaves as Lake Huron did, the alewife population in southern Lake Michigan should stabilize, according to Dr. Smith. Die-offs will be seen each year as always, but should be hardly noticeable, as is now the case in Lake Huron, Dr. Smith believes.

EXTENT OF THE ALEWIFE DIE-OFF IN THE GREAT LAKES, 1967

According to Greenwood (11), alewife mortality was reported from Saginaw Bay (Lake Huron) during this year. He also reported that an alewife kill was noted in Lake Erie during the latter part of the past winter.

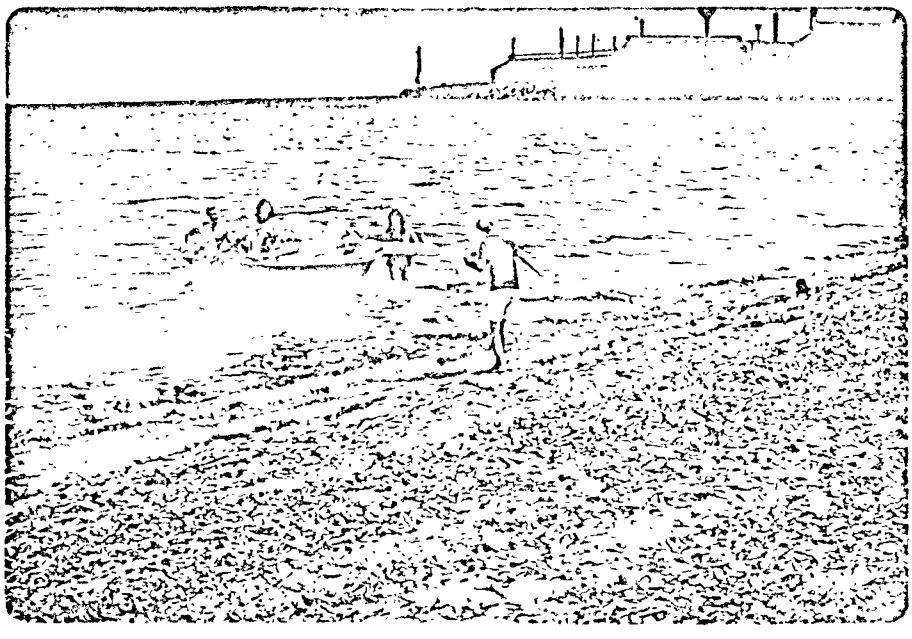
According to Smith (12), serious alewife die-offs have occurred in Lakes Ontario, Erie, and Huron in the past. It is probable that the peak years of abundance have occurred in these lakes. However, annual kills still occur.

Although neither Greenwood nor Smith estimated the alewife kills in each of these lakes in 1967, Smith (12) stated that the current die-off in southern Lake Michigan was the greatest of any local die-off that he had observed in the Great Lakes.

INTERFERENCE TO WATER USES BY THE ALEWIFE DIE-OFF

For at least the past half-century, the alewife has been a conspicuous nuisance in some of the Great Lakes. Nearly every summer large numbers die and, drifting to shore, clutter the beaches. They are not only unsightly and unpleasant to encounter while swimming but also give the water and beaches a strong fishy odor. Bones of decomposed alewives can be a hazard to feet of bathers. The economic loss caused by the littering of beaches and harbors with dead alewives is difficult to estimate. During the present problem in Lake Michigan in the Chicago area, many men of the park district and the department of streets and sanitation have been used to cart away and bury tons of odorous fish. By July 17, 1967, the park district had buried 3,500 cubic yards of fish either under the beaches or in private or public dumps. Workers had used 5,000 gallons of deodorant to try to overcome the smell (13).

Alewives clog intake pipes and filter screens leading into water treatment plants, electric utilities and factories. A steel plant on the southern shore of Lake Michigan estimated a loss of approximately half a million dollars a day for about 10 days in April 1966 when cleaning screens on the cooling water system were unable to cope with alewives entering the intakes. The screening system was inadequate even though it removed 60 tons of fish per day. Electric power generating plants in Illinois were seriously affected at about the same time when it became necessary to alternately shut down half the generators while cooling water screens on the other half were cleaned. In April 1965, Chicago's new Central District Filtration Plant operated at reduced capacity when alewives caused breakdowns to 20 per cent of the cleaning screens which were handling 10 tons of fish per hour. This water system was protected in 1966 by the installation of an alewife diversion system (14).



A water skiier tiptoes over dead alewives littering the 79th Street beach in Chicago to get to the boat. This is one example of how the massive fish die-off has interfered with recreational uses of the beach front. 6-20-67

The alewife is troublesome to Great Lakes commercial fishermen because they snag easily in perch gill nets (15). Further, alewives compete with ciscos, a more valuable commercial fish. A decline in the shallow water cisco has paralleled an increase in the number of alewives in South Bay (Lake Huron), Saginaw Bay (Lake Huron) and Green Bay (Lake Michigan). The rapid build-up of alewives in the Great Lakes is thought to be the result of the disturbed inter-relationships between species caused by the sea lamprey and by over fishing. Lake trout and burbot are predators of the alewife. The recent decimation of their numbers probably resulted in the increase in alewife populations.

RESEARCH AND STUDIES ON THE ALEWIFE PROBLEM

Dr. Smith, Mr. Greenwood, and other personnel of the U. S. Bureau of Commercial Fisheries, Ann Arbor, Michigan, have studied the alewife extensively. Dr. Smith (12) stated that other studies being conducted on the alewife includes a study on the ecology of the alewife in northern Green Bay by the Michigan Institute for Fisheries Research; a study on the diurnal feeding movements of the alewife in the Milwaukee area by the University of Wisconsin, and a study of the food of the coho salmon and the lake trout in relation to the alewife by the Michigan Institute for Fisheries Research.

Various Great Lakes states have revised commercial fishing regulations to permit a larger harvest of the alewife and to protect such alewife predators as the lake trout, coho salmon, and chinook salmon (15).

Greenwood stated that the exploratory branch of the U. S. Bureau of Commercial Fisheries has been conducting studies in Lake Michigan since 1962. Some of the objectives of the agency are to obtain information on the availability of the alewife for commercial uses and to obtain information on more economical ways of processing and handling alewives. In order to obtain information on the annual relative abundance of fish, samples of the various year classes of the fish are collected each November in the Saugatuck area.

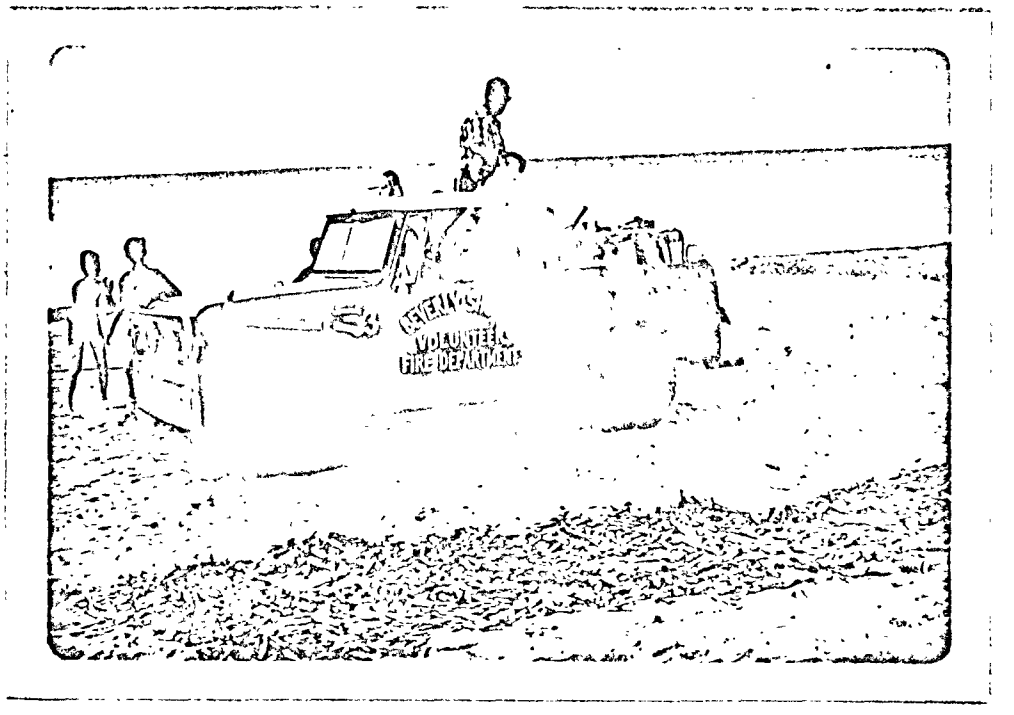
Mr. Greenwood states that the Province of Ontario is making a study of alewives in the island area of Lake Ontario.

DISPOSAL AND CONTROL METHODS ON THE ALEWIFE PROBLEM

The disposal of dead and decaying alewives demands immediate action of agencies involved with recreation on beaches and in harbors. Usually, the fish are raked up or scraped up by hand shovels and/or tractor lifts and placed into trucks. They are then transported to public or private dumps where they are buried. In some cases, the fish are buried to a depth of 4 or 5 feet on the beach. Equipment includes sand sifters to separate fish from sand. Although disposal might include burning of dead alewives, such action would result in air pollution. Deodorants have been applied to dead fish and the beaches to reduce the stench of decomposition. In some cases, chemicals are used on beaches to control fly maggots in the dead fish.

The use of trawlers to catch and remove the fish before they reach the beaches has been suggested. Nets placed around water intakes can prevent alewives from entering the water system. Chicago protected its water supply by installation of an alewife diversion system in 1966 (14).

Methods of alewife control are varied. Alewives can be processed into animal food and fish meal. Commercial trawling is an effective way of catching alewives, according to Greenwood (10). He estimates that during this year 50,000,000 pounds of alewives will be taken from Lake Michigan and processed at grinding plants now operating at Menominee, Michigan, Milwaukee and Pensaukee, Wisconsin. Possible future expansion in the business may result in the removal of considerable numbers of fish in their first and second years of life and reduce the number which seem to die naturally in the third year of life. Fish predators can aid in the control of alewives. Lake trout, coho salmon and chinook salmon are predators of the alewife. According



A Beverly Shores Volunteer Fire Department truck sprays deodorant on dead alewives to reduce the smell of rotting fish. 6-26-67

to Greenwood (15), the U. S. Great Lakes Fisheries Commission stocked 2.1 million lake trout in Lake Michigan in 1965, 1.7 million in 1966 and 1.8 million in 1967. The State of Michigan stocked 700,000 coho in Lake Michigan in 1966 and 1 million in 1967. In addition that State stocked 800,000 chinook salmon in Lake Michigan in 1967 (11). Evidently some have done quite well, for sizable numbers of cohos have migrated to southern Lake Michigan to feed on the large numbers of alewives there. Unfortunately, many were netted by commercial fishermen in Indiana waters. To correct the situation, the Indiana Conservation Department has placed a ban on commercial fishing for coho and chinook salmon, following bans already in effect for Michigan, Wisconsin and Illinois (15).

Smith (4) summarized the program of stocking Lake Michigan with desirable fish species as follows:

"A vigorous program is underway to reestablish climax predators in Lake Michigan to create a predator-prey balance with the alewife. Sea lamprey control in Lake Michigan will be completed by early 1967. Lake trout stocking by the states and the federal government, started in 1965, has reached nearly 2 million fingerlings annually, and will be continued until natural reproduction is well established. Michigan started stocking fingerling coho salmon in Lake Michigan in 1966 with apparent success, and has initiated plans to introduce chinook salmon in the near future. Both Michigan and Wisconsin are increasing their plants of steelhead trout in Lake Michigan tributaries. Although the steelhead does not occupy the deepest areas of the lake, it is expected that it will feed heavily on alewives. The Province of Ontario has started to make large introductions of splake in Lake Huron and these will have free access to Lake Michigan if successful. The splake is a lake trout-brook trout hybrid that has been

selected for many generations to develop a strain that will occupy deep water, grow fast, and mature early. Michigan and Ontario have also initiated experimental introductions of kokanee in the Lake Michigan watershed and in Georgian Bay, Lake Huron. Although it is uncertain where the kokanee will live in the Great Lakes, they will probably compete with the alewife.

"It seems unlikely that all of these introductions will meet with great success. It is certain, however, that the sea lamprey will be controlled, as it has been in Lake Superior, and that conditions again will be favorable for large predators in the deepwater areas. Establishment of at least the lake trout seems to be assured because of its rapid recovery in Lake Superior that followed completion of the initial sea lamprey control measures in 1961. The successful establishment of at least one additional major predator in the deepwater area would place even greater pressure on the alewife as the principal forage species. Thus, the alewife which reached the peak of its population explosion in the mid-1960's and is subjected to heavy commercial exploitation, certainly must decline as substantial populations of predators are established."

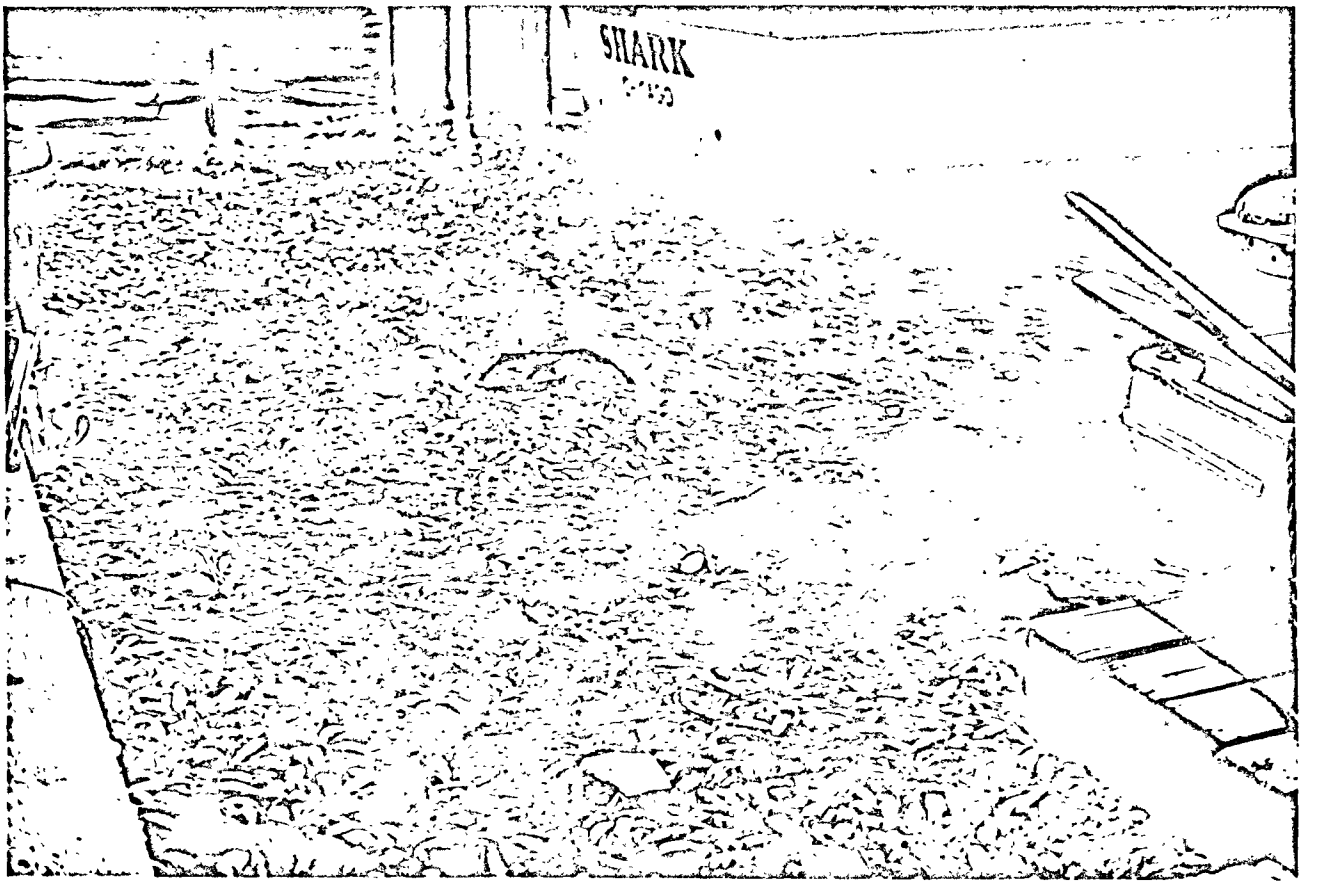
In another communication, Dr. Smith also observed that "we know that the shore waters of Lake Michigan, particularly in the southern end, are becoming richer and the carp that thrive under such conditions are becoming more abundant. Other species favored by this enrichment may also become more abundant. Species that increase under those conditions are usually 'rough fish' and should be harvested as they often compete to the disadvantage of game fish."

CONGRESSIONAL CONCERN OVER THE ALEWIFE PROBLEM

As the dimensions of the alewife die-off became known, Congressional interest grew. There was a public clamor for action to clean up the beaches. Sen. Gaylord Nelson (D., Wis.) introduced Senate Bill 2123 on July 17 asking for $5 million to seek to control the alewife problem. The bill would provide matching grants to states for research into ways to reduce the tens of billions of alewives in the Great Lakes. Nearly all the 16 senators from the states bordering on the lakes will back the legislation, according to Sen. Nelson's office. A companion measure, HR 4793, was sponsored in the House of Representatives by Rep. Clement J. Zablocki (D., Wis.). A similar bill has also been introduced by Rep. Henry C. Schadeberg (R.,Wis.).

Congressional inquiries were directed to the Federal Water Pollution Control Administration from elected officials from throughout the Great Lakes. Inquiries came from Sen. William Proxmire (D., Wis.); Senators Philip A. Hart and Robert P. Griffin of Michigan; Senators Birch E. Bayh and Vance Hartke of Indiana; Senators Everett M. Dirksen and Charles H. Percy of Illinois; Senators Eugene J. McCarthy and Walter F. Mondale of Minnesota; and Sen. Robert Kennedy of New York. Congressmen who have been in touch with FWPCA personnel include Rep. Raymond J. Madden (D., Ind.) and Rep. William A. Steiger (R., Wis.).

Sen. Hartke (D., Ind.), another sponsor of the alewife control bill, toured beaches in Michigan City, and in Gary with that community's mayor, A. Martin Katz. Afterward, Sen. Hartke said he never fully appreciated the problem until he actually saw and smelled the fish.



Chicago's Burnham Harbor on June 30 was a stinking mass of dead alewives and algae. 6-30-67

Letters and telephone calls from concerned resort and summer home owners and vacationers have also rained into the Great Lakes Regional Office, FWPCA, in Chicago.

A number of Congressmen inquired about the possible use of members of the Job Corps, who are enrolled in one of the programs conducted by the Office of Economic Opportunity. Approximately 110 Job Corps members have since been engaged in clean-up activities in the Indiana communities of Gary, East Chicago, Whiting, Beverly Shores, and Michigan City. Along the Michigan shoreline between Benton Harbor and Ludington, between 40 and 100 Corpsmen have been deployed for the clean-up. Twenty-five Job Corpsmen from the Camp McCoy center in Sparta, Wis., were the latest work force to help with disposal of the fish. They arrived at the Illinois Beach State Park near Zion, Ill., on July 24 to begin clean-up operations. Job Corps aid had been requested by Senators Dirksen and Percy. Job Corps workers are also available for duty in other states if their services are requested.

Sen. Bayh inspected the alewife problem in Lake Michigan on July 21, when he went on a two-hour boat tour with federal, state and local officials, traveling from East Chicago to Michigan City, Ind. Accompanying Sen. Bayh on the inspection were: H. W. Poston, Great Lakes Regional Director, FWPCA; Raymond Clevenger, Chairman of the Great Lakes Basin Commission of the President's Water Resources Council; Ernest Premetz, Deputy Regional Director of the Bureau of Commercial Fisheries and Wildlife; Blucher A. Poole, chief of environmental sanitation for the Indiana Board of Health; John Mitchell, director of the Indiana Department of Natural Resources, and

John Nicosia, mayor of East Chicago.

Representatives from the Allis-Chalmers Co., whose equipment is currently used by the cities of Gary and Michigan City to remove fish from the beaches, and Aquatic Controls Corp., whose machinery removes fish from the water, were also present to brief the group.

Sen. Bayh, who is a cosponsor of the bill to provide $5 million for alewife control, said he will also support efforts to obtain funds for clearing the alewives from the beaches. He said that while it is too late to prevent alewives from littering the beaches and shoreline this year, the $5 million study will help to alleviate the problem in future years.

In addition, he added, ways must be found to help local officials clear the alewives off their beaches to prevent possible health and pollution problems and to salvage recreational beach uses.

Rep. Zablocki has also called on Mr. Clevenger, as Chairman of the Great Lakes Basin Commission, to arrange a conference on the alewife problem so that information may be exchanged and efforts for dealing with the crisis coordinated between the various levels of government.

CONCLUSIONS

Big alewife die-offs have occurred in Lakes Ontario, Erie, and Huron in the past, with kills of lesser magnitude occurring in these lakes the last few years. The alewife die-off that occurred in Lake Michigan during June and July 1967, however, was of unprecedented proportions. The great size of the die-off is no doubt linked in some way with the unstable balance that exists between the alewives and their predators. Unchecked by natural predators, the alewife population appears to have exploded.

Causes of this massive die-off, though, remain speculative. Many theories have been advanced to explain it and past die-offs, including: starvation, temperature shock during migration from the cold deep waters to shallow warm waters for spawning, natural death at the end of the life span, toxic plankton blooms, oxygen depletion in spawning areas, and thyroid exhaustion.

There is an obvious need for more long-term research into the problem. While the alewife has been a conspicuous nuisance in most of the Great Lakes for many years, the 1967 die-off presented a huge disposal problem never before encountered. While all available evidence indicates that water pollution is in no way responsible for the deaths, the alewives do become a pollution problem when they die and are washed ashore, littering beaches and harbors to interfer with many water uses. The unsightly appearance and obnoxious smell of decaying alewife carcasses are repugnant to bathers, boaters, and other users of water. Alewives have clogged intake pipes and filter screens leading into water treatment plants, electric utilities and factories. They are troublesome to commercial fishermen because they gill easily in perch nets, and they have replaced other more valuable fish such as the cisco and chub.

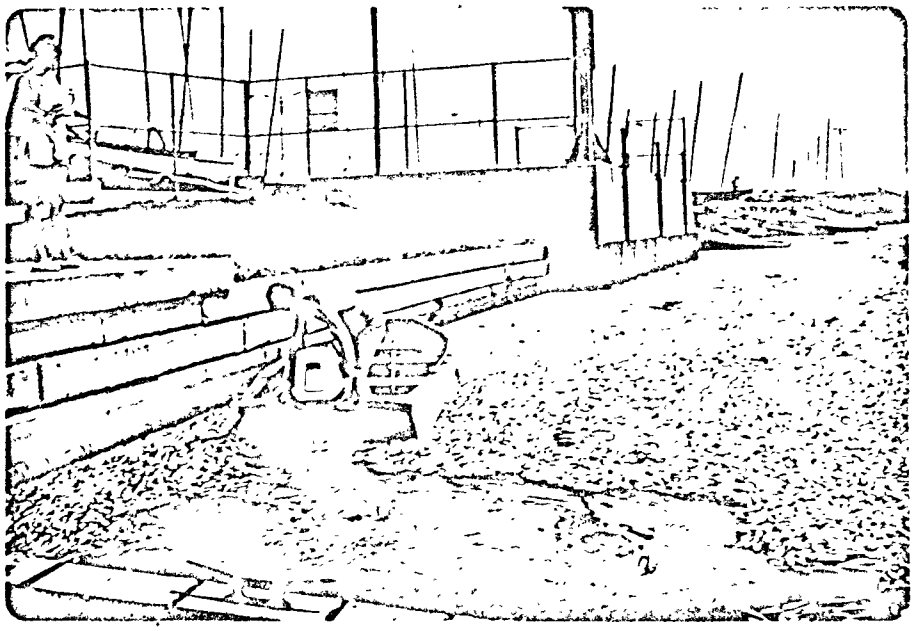
Restocking of fish that prey on the alewives and increased commercial fishing for them should prove helpful in restoring a balanced aquatic environment to bring the alewife population under control.

There is also a need for programs which will concern themselves with the more immediate problems of cleaning up the beaches and finding ways of removing the fish from the water before they reach the shore. In this regard, increased trawling for the fish should also be considered.

The Secretary of the Interior has appointed a six-man task force, headed by Dr. Stanley A. Cain, Assistant Secretary of the Interior for Fish, Wildlife and Parks, to study all aspects of the problem.

Studies of the alewife are also being conducted at the U. S. Bureau of Commercial Fisheries, Ann Arbor; by the University of Wisconsin; by the Michigan Institute for Fisheries Research, and by some of the Provinces of Canada.

Various Great Lakes States have passed regulations to encourage heavier harvest of alewives and to prevent commercial exploitation of alewife predators. Such measures, however, are not expected to produce immediate results, since it is believed that it will take some time for the predators to establish themselves in the lake waters in sufficient numbers to exercise a controlling influence over the alewife population.



A boat owner tries to clean out alewives which have collected in Chicago's Burnham Harbor with an outboard motor. 6-23-67

APPENDIX

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