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EFFECT OF OIL POLLUTION  
ON MARINE AND WILD LIFE

By

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and

P. N. HARDING, *formerly with the American Steamship Association*

APPENDIX V TO THE REPORT OF THE U. S. COMMISSIONER  
OF FISHERIES FOR 1925



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## INTRODUCTION

During the latter part of 1922 and the early part of 1923 the Bureau of Mines, then in the Department of the Interior, in cooperation with the American Petroleum Institute and the American Steamship Owners Association, conducted an investigation of the pollution by oil of the coastal waters of the United States. Although the investigation was essentially of a technical character, so many complaints and reports were received relative to the deleterious effect of oil pollution on marine and wild life that it became necessary to devote particular attention to this phase of the subject. With the aid of specialists in that line of endeavor the authors have attempted to summarize the situation with respect to the effect of oil pollution on marine and wild life.

The authors wish to acknowledge their indebtedness to the officials of the organizations that cooperated in the investigation as a whole, to the Bureau of Fisheries, and in particular to Dr. H. F. Moore, formerly Deputy Commissioner of Fisheries. They are also indebted to Dr. Thurlow C. Nelson, of Rutgers College, New Brunswick, N. J., and to Dr. David L. Belding, biologist in the department of conservation of the State of Massachusetts. Appreciation is also expressed to other Government departments that aided in the preparation of this phase of the subject.

<sup>1</sup>Appendix V to the Report of the U. S. Commissioner of Fisheries for 1925. B. F. Doc. No. 995. Published by permission of the Director of the Bureau of Mines, Department of Commerce.

Attention is called to the fact that this paper deals only with oil pollution as it occurs on the Atlantic and Gulf coasts. No attempt has been made to deal with other forms of pollution or to investigate effects of oil contamination in inland waters.

### GENERAL DISCUSSION

The effect of oil pollution on marine and wild life has received much attention, due to numerous and widespread reports that the fishing industry, particularly the oyster industry, has been adversely affected, and that large numbers of wild fowl have been killed as a result of oil pollution. In the course of the present investigation the authors endeavored to secure additional information on the subject by means of interviews, inspections, and correspondence.

### ECONOMIC IMPORTANCE OF COASTAL AQUATIC LIFE

The total value to the fishermen of the fishery products of the United States approximates \$90,000,000 annually. The oyster industry alone produces over \$14,000,000 worth of food every year, estimated to be the equivalent in food value of 254,000 dressed steers. The most important aspect of the situation, however, lies in the vital importance of aquatic life as a source of food and the possible effect which oil pollution may have upon this source. It is stated that the nitrates and other salts essential for plant growth, which are produced in the decomposition of sewage, and those which are brought to the streams by the leaching action of ground water ultimately pass out to sea and are lost unless utilized in coastal waters as a factor in the growth of marine plants and animals.

### EFFECT OF OIL POLLUTION IN DRIVING FISH FROM DOMESTIC WATERS

It has been asserted that practically all of our badly polluted waters, where no signs of fish are now to be found, were good fishing waters before the development of present-day congested manufacturing and shipping conditions. The increasing use of oil fuel is said to be largely responsible for the marked decline of the fisheries in many localities. As indicating that the reduction and control of pollution will be followed by a return of former fishing activities, it has been stated that during the great depression in industrial activities some two or three years ago the closing of entire industrial communities was accompanied by a reduction in pollution of the streams, and consequently fish were again found in quantity in many of their former habitats.

### TOXIC PROPERTIES OF OILY DISCHARGES

Experiments made by the Massachusetts department of conservation on the effect of industrial wastes on fish life indicated that a mixture of 1 part crude petroleum to 1,000 parts of water did not immediately affect brook trout.<sup>2</sup> On the other hand, tarry matter

<sup>2</sup> Pub. Doc. No. 25, Commonwealth of Massachusetts, Annual Report of the Division of Fisheries and Game for the Year Ended Nov. 30, 1922.

from gas wastes with a concentration of 1 part in 400,000 killed yellow perch in 12 days.<sup>3</sup> It may be pointed out that the chemical nature of this tarry matter probably differs from the waste oil from oil-burning steamers.

There is considerable difference of opinion among investigators regarding the toxic effect of oily discharges. One states<sup>4</sup> that the amounts of petroleum and certain other oils that are sufficient to cause any deleterious effects upon oysters, other than oyster larvae, are surprisingly large. On the other hand, Dr. Thurlow C. Nelson, an authority on the culture of oysters, maintains that oil, gallon for gallon as thrown out, is the most destructive to aquatic life of all foreign substances now entering our coastal waters.<sup>5</sup>

#### EFFECTS OF OIL ON FISH, SHELLFISH, AND FOWL

Fish, shellfish, and fowl are affected quite differently by oil. So far as the fish are concerned, pollution by oil not only imparts an obnoxious taste, unfitting them for the market, but the gear used in the fishing industry is befouled and injured. One investigator doubts that there is any real proof that oil directly destroys adult fish. He states that the effect of oil on fish may be twofold<sup>4</sup>—(1) the direct effect on the fish themselves and (2) the indirect effect as shown by changes in environment, food, and migratory habits. He suggests that with regard to migratory fish the presence of oil may deflect them from the coastal waters, and thus affect both the spawning and the fishing industry. As just pointed out, the indirect effect is believed to be brought about largely through the changes that take place in their environment affecting spawning grounds, food, and migratory habits. Unsuitable environment, such as would result from oil waste, may be the direct cause of driving these fish to other waters; or the same effect may be produced indirectly because the smaller fish and the aquatic organisms that serve as their food supply have either been destroyed or driven away.

In connection with the direct effect on fish, the authors desire to state that at least in one instance fish were found struggling in an inclosed body of water badly polluted with oil, apparently suffocating and unable to right themselves and swim away. The harbor master at Bridgeport, Conn., has seen bluefish and mackerel dead in large numbers on the inner side of the inner breakwater, and he can account for this only by the fish coming in contact with the polluted river waters. He stated that boats coming into Bridgeport with large numbers of live cod on board now close the tank holes before entering the harbor. Ordinarily the holes would be left open to insure a free circulation of water for the fish. It was found, however, that when Bridgeport harbor was entered with these holes open over two-thirds of the cod died. It is probable, however, that other industrial wastes besides oil are responsible for much of the damage done.

<sup>3</sup> Marsh, United States Geological Survey, Water Supply Papers 186-192, 1907, p. 337.

<sup>4</sup> Personal communication to the authors.

<sup>5</sup> Personal communication to the authors. Doctor Nelson's more complete statement is given later in this paper.

The effect of oil wastes on shellfish can be more accurately described.<sup>4</sup> During the first part of its existence, before it sets, the young mollusk is a free-swimming larva in the water. During this stage it is especially susceptible to the slightest change in environment. The presence of oil waste would cause the destruction of these larval forms, which swim immediately beneath the water surface. He believes that oil would kill adult shellfish only when present in considerable amounts. He explained that the process of setting of oysters may be prevented by any slimy material, and the presence of oil would undoubtedly have a deleterious effect in this respect.

Tests have shown that adult oysters can be placed in an appreciable amount of water-gas tar without immediately perishing. Apparently no actual deaths of mollusks from oil wastes have been noted by the Massachusetts division of fish and game, but clams have been rendered unpalatable and unfit for food where oil has contaminated the flats.

The destructive action of oil pollution on fowl was officially reported in California in 1917 and along the eastern coast in 1920 and 1921. It is stated that the birds, either in walking on the flats or resting on the oil-covered water of tide pools, come in direct contact with the material, which tenaciously sticks to their legs, wings, and on the sides of their bodies. As the bird endeavors to remove this material, its neck, head, and beak become more or less contaminated with it. The feathers are matted together, and it is stated that when this occurs with the wings the birds become helpless. Apparently they find it impossible to fly, or at least to fly in the normal manner, and they can only walk or roll over the flats. The oil not only causes matting of the feathers, but is reported to penetrate to the skin, causing irritation. It is said that a bird thus disabled will inevitably perish. Death is stated to be due to the inability to (1) navigate normally, (2) obtain food, and (3) maintain their normal body temperature.

The vice president of the American Game Protective and Propagation Association of New York stated that if birds get only a small spot of oil on them death seems to be just as certain though it comes slowly. He has seen many ducks dead with only a small spot of oil on them, and other birds that had only a small patch of feathers matted with oil.

#### PRESENT STATUS OF OIL POLLUTION

It would appear, therefore, that oil pollution has considerable effect upon the edible qualities of aquatic animals and may affect the migratory habits of fish; it is detrimental to shellfish by reason of destroying the larval forms and rendering the adult mollusks unfit for food. With regard to water fowl, it appears to be a cause of considerable destruction, rendering the birds helpless through its mechanical action on the feathers. It has been stated that when birds are not actually killed as a result of contact with the oil they are rendered unfit for food due to the oil taint.

A survey of the situation along the Atlantic and Gulf coasts indicates that adverse conditions due to oil pollution, as affecting marine and wild life, were widespread, practically every important

<sup>4</sup> Personal communication to the authors.

coastal water being affected to some extent. Conditions, in general, were at their worst during and immediately following the war, when pollution was undoubtedly at its height. The authors are led to believe that, on the whole, conditions during 1922 were somewhat better than in the preceding year.

While it is possible that considerable destruction of wild bird life may be chargeable to pollution of waters by heavy oil and tarlike deposits, the authors are of the belief that oil pollution is only partly responsible for the losses in the fish and shellfish industries. In the waters adjacent to the important industrial centers it is believed that these losses will be found to be due as much to other industrial wastes as to oil.

#### OIL POLLUTION AND CONSERVATION OF FOOD RESOURCES

An excellent picture of the effect of pollution on all forms of aquatic life in coastal waters is contained in a paper<sup>6</sup> by Dr. Thurlow C. Nelson, of Rutgers College, New Brunswick, N. J., read before the laboratory section of the American Public Health Association at San Francisco, Calif., on September 13, 1920.

Doctor Nelson states that the effects of human wastes and of trade effluents upon a body of water are entirely different. Domestic sewage usually contains little or nothing that is toxic to aquatic organisms. Putrefactive and other bacteria, aided by a host of animal forms, decompose the sewage and render it available as plant food. The resulting stimulation of plant growth is followed by an increase in numbers and often in size of the animals that feed upon them. Shellfish growing in waters contaminated with human wastes are therefore usually very fat, owing to the presence of great numbers of food organisms which in turn are deriving their nutriment from the products of decomposition of the sewage.

The wastes from factories and manufacturing plants of all kinds present an entirely different problem. Here we are dealing with effluents which, in general, are highly toxic to aquatic organisms. For convenience these wastes may be divided into four classes: (1) Acid or alkaline, (2) oil and oil waste, (3) various chemical substances in solution, and (4) precipitates held in suspension. Doctor Nelson goes on to point out that oil, by spreading a film over the surface of the water or by coating animals and plants with an impenetrable layer, ultimately kills them, either by direct contact or by preventing free interchange of oxygen and carbon dioxide. It is stated that a film of oil on the surface of the water will kill molluscan larvæ within a few hours, owing largely to the habit of these organisms of swimming close to the surface. In the opinion of this writer the disposal of industrial wastes in such a way as to render the effluents harmless when emptied into a stream and still not impose an undue tax upon the industries concerned is a problem that will require the best efforts of chemists and engineers for years to come.

#### REPORTS ON OIL POLLUTION FROM VARIOUS SOURCES

During the course of this investigation, which was conducted along the coast from Boston, Mass., to Galveston, Tex., the authors held a large number of interviews and received many communications.

<sup>6</sup> "Some aspects of pollution as affecting oyster propagation."

Only a very brief account of the more important of these is given herein.

The Bureau of Fisheries wrote to the Director of the Bureau of Mines as follows:

\* \* \*. It is the opinion of the bureau that oil pollutions are detrimental to the coastal fisheries, not only from their destructive and repellant effects on fishes and economic invertebrates but in affecting the products of the fisheries with obnoxious tastes, unfitting them for the market, and in fouling and injuring the gear used in the fishing industry.

A biologist of the division of fish and game, Massachusetts State department of conservation, expressed the opinion that oil will kill adult shellfish only when it is present in considerable amounts. On the other hand, the young larvæ would probably be killed by any appreciable quantities of oil. He explained that the process of setting of oysters may be prevented by any slimy material, and oil would undoubtedly have a deleterious effect in this respect. This authority referred to some experimental work on the discharge of wastes from certain gas works into waters at Providence, R. I. The results of this work seem to indicate that under certain conditions shellfish stand a surprising amount of this type of pollution without injury to themselves.

At Providence, R. I., the investigators were told by oystermen that the effect of oil pollution on oysters in that locality is very pronounced. It is questionable just how far the oysters, growing at a considerable distance below the surface of the water, are affected by oil on the surface. In this connection the authors' attention was called to the case against a local petroleum company about three years ago. At the trial a well-known authority presented evidence to show the deleterious effect of oil on oysters, but the defendant had one of the piles pulled up in one of the badly polluted locations and oysters were found growing on the lower portion of it.

At Bridgeport, Conn., officials of an oyster company informed the authors that the last general oyster set in Long Island Sound was in 1914, so that there may be some connection between the disappearance of the oysters in this locality and the introduction of oil as fuel. One of these officials was of the opinion that just as much damage is done by wastes from chemical and other industrial plants as by oil.

A former Connecticut State inspector of oyster beds pointed out that conditions in the waters in the neighborhood of Bridgeport, Conn., are very bad. He believes, however, that these conditions are due as much to sewage and other industrial wastes as to oil. He pointed out that oysters can not be matured in the neighborhood of Bridgeport and therefore the locality is now used merely as a planting ground or seeding area, and when the oysters are partially grown they are transported to other localities.

The harbor master at Bridgeport has seen bluefish and mackerel dead in large numbers on the inner side of the inner breakwater, and he can account for this only by the fish coming in contact with the polluted river water.

The manager of an oyster-farm company in Milford, Conn., wrote the authors as follows:

We are not affected as much by oil pollution as we are by the combined wastes from factories, municipalities, and oils.



He goes on to state that his immediate vicinity has the average number of wild fowl found in emaciated condition and sometimes dead with their feathers saturated with heavy oils. His observations regarding the effects of oil on fish and shellfish coincide closely with the views already given on this subject.

The supervisor of New York Harbor, who has direct administration of the laws relative to the throwing of waste material into the harbor, informed the authors that he had reports that certain fish were now caught in the harbor for the first time in four years.

One investigator writes as follows:<sup>4</sup>

\* \* \*. I made some rather extended investigations relative to this matter, but my work was all directed to the study of the effect of certain oils upon shellfish, chiefly oysters.

My results can be summarized briefly by saying that the amounts of petroleum and certain other oils that are sufficient to cause any deleterious effects upon oysters, other than oyster larvæ, are suprisingly large. These amounts are far in excess of any quantities that could possibly be held in sand or mud on the bottoms of rivers or bays.

According to a report prepared for the authors by E. F. Moran, of New York, fishing in the harbor and adjacent waters had become insignificant by 1921; while an officer of Coast Guard station No. 92 (Rockaway Beach, Long Island), reported that ducks and birds are made helpless when in oil. He had had personal experience with wild fowl unable to fly on account of oil-covered feathers. The vice president of the American Game Protective and Propagation Association, New York, has seen many wild ducks that have come in contact with floating oil, both along the seaboard and in the interior. In his opinion this menace to wild water fowl kills thousands of ducks every year. Once the feathers of the bird become coated with oil he is doomed, due to loss of the power of flight and consequent inability to obtain food.

The commissioner of fisheries of the Commonwealth of Pennsylvania wrote as follows:

\* \* \*. This department is very much interested in the subject of oil pollution, not only of navigable waters but of inland waters as well, and our surveys show that in the oil-producing regions very much harm has been done by the wastes from the wells and refineries. This waste not only causes a thin film of oil to float on the surface of the streams, which, of course, is death to the tiny fishes, but it also creates a condition on the bottom of the stream that is detrimental and destructive so far as the natural propagation of the fish is concerned.

The surveys made by this department along the Delaware River in the tidal section lead us to believe that the oil and sludge from refineries and oil-carrying vessels has done more to destroy fishing in that portion of the river than has any other single cause. It has become so serious during the last few years that this department has been unable to collect any of the spawn of the shad, whereas in former years, before we had this to contend with, we were able to collect anywhere from 25,000,000 to 75,000,000 eggs during a season, and shad fishing was worth while.

The president of the New Jersey State fish and game commission stated that he was not in a position to furnish authentic data regarding the condition that existed on the New Jersey coast. He has been more concerned with the pollution of inland streams, which affects the planting of fish by his department. He did state, however, that due to industrial and oil pollution from ships the Hacken-

<sup>4</sup> Personal communication to the authors.

sack and Passaic Rivers and Newark Bay are in such condition that absolutely no fish life of any kind is in them at the present time, whereas 20 years ago these waters were the habitat of all species of edible fish that were native to this coast.

The director of the department of conservation and development of New Jersey stated that while his department has a general knowledge of existing oil pollution in some of the waters bordering the State it has no specific information that would be of value to the present investigation.

Dr. Thurlow C. Nelson, an authority on the culture of oysters, has submitted to the authors a very complete statement. The following is taken from Doctor Nelson's letter:

\* \* \*. The following observations include only those in which it is definitely known that no foreign substances other than oil were present:

1. Oil is, gallon for gallon as thrown out, the most destructive to aquatic life of all the foreign substances now entering our coastal waters. By reason of its physical nature the factor of dilution, which is so important in reducing the harmful effects of other foreign substances, is largely eliminated. Whereas most wastes other than oil are quite uniformly distributed throughout the water, oil is concentrated at two points—on the surface film and at the bottom. Its passage from the surface to the bottom, difficult of comprehension by the layman, is relatively rapid and is accomplished by absorption on the surface of the particles of dirt, sand, and detritus present in the water. Large amounts of suspended matter are stirred up by winds and currents, and these sink during periods of calm and slack tidal water, carrying down to the bottom a load of oil.

Biologically, the surface and the bottom of our coastal waters are the regions of greatest activity. At the surface free interchange of oxygen and of other gases occurs, and here, at some time in their development are found the eggs or larval stages, or both, of many of the common fish, shellfish, and the plant and animal organisms upon which the young and adults feed. Oil, though it be present in only the thinnest film, is thus brought into contact with the living organisms and kills them either through direct contact or through reducing free oxidation, or through being taken in with the food. Such larvæ of shellfish as escape the oil at the surface will, when the time comes to attach to the bottom, find this unsuitable on account of the oil which is accumulated there, and will therefore perish.

2. Laboratory experiments have shown that a film of crude oil just sufficient to cover the surface will within an hour cause the death of clam and oyster larvæ at a temperature of 75° F. This apparently is due to the habit of these organisms of feeding for short periods at a time with the cilia of the velum lashing through the surface film. Feeding experiments show that oyster larvæ will take into the gullet any particles of sufficient fineness, regardless of their nature.

To check these experiments we have the following field observations: Great Bay, N. J., just below the town of Tuckerton, receives the waters of the Mullica River, the largest stream within the State. Situated as they are in the cedar swamps and barren regions of southern New Jersey, neither the Mullica River nor Great Bay receives any sewage or industrial wastes. Aside from an occasional oysterman's shack, there are no settlements on the banks of either, save only a few small settlements near the headwaters of the river many miles above the oyster beds. A large menhaden-oil plant is located on Seven Islands in the eastern part of Great Bay about 2 miles west of New Inlet (Little Egg Harbor Inlet). Until the war this plant was operated in such a manner as to cause no effect on the surrounding waters. From time to time excellent sets of oysters occurred within a short distance of the factory, and sets in the channel below Seven Islands were frequent.

Following the outbreak of the war, late in 1917, this plant began to receive garbage from Atlantic City, which was towed there on great scows. These were anchored alongside the factory sometimes for days, during which, in warm weather especially, large quantities of oil and grease flowed overboard. At times the surface of Great Bay was covered by so heavy a film of oil that oystermen and clambers had difficulty in holding the stales of their tongs, they

were so slippery. Since this plant has been rendering garbage, the only sets of oysters have been in the upper Mullica River some 10 miles from the plant. The former great natural oyster bed at the Gravelling, at the mouth of the river, has not received any set of consequence during this same period, though formerly it was one of the most productive in the State.

We have been studying the Great Bay region since 1900, and during this time there has been no apparent change in conditions there other than the change from fish rendering to garbage salvage, as indicated. It is perhaps significant that great numbers of mussel larvæ are found in late April or early May, when the weather is as yet not warm enough to cause much loss of grease from the garbage scows.

3. Regarding the effects of oil upon adult oysters let me cite experiments which I performed in 1920 in preparation for testimony in the case against an oil company at Providence, R. I., in May, 1921. The oysters were kept in two tanks of bay water of known purity; one tank served as control, the other was kept covered by a film of oil. The water in both tanks was frequently agitated to simulate wave action, and at no time did the oxygen saturation fall below 80 per cent. (It has been shown that oysters do not suffer until the saturation falls below about 30 per cent.) After 15 days the oysters from the two tanks were opened and compared. Those from the oil-covered tank showed marked contraction of the mantle, the blood vessels revealed many bluish nodules characteristic of oysters living under unfavorable conditions, and the bodies of the oysters were distinctly thinner and poorer than those of the controls. Preserved samples of each lot show the difference clearly even now.

Mitchell<sup>7</sup> failed to find effect of water-gas tar upon oysters. These experiments are open to the objection that clear running water was used and that practically all of the tar was soon deposited on the sides of the aquarium. If turbid water such as that found on most oyster beds had been used, and if this had been kept in agitation as is the case in wave action, then he would, I am sure, have obtained a different result.

4. Damage to adult oysters from oil is of two kinds—(a) a direct result of ingestion of oil along with the minute particles of detritus which form so large a part of the oyster's food, and (b) an indirect result of oil upon the plant and animal organisms that live upon the oyster's shell and which are most important sources of nutriment. Eventually, as more and more oil is carried down to the bottom, the shells of the oysters and the surrounding bottom become so thoroughly impregnated with the oil that the organisms used as food by the oyster can not live and multiply.

5. The vast oyster industry of Maurice River Cove, Delaware Bay, which did a \$7,000,000 business last year, is threatened by oil and by oil alone. This region is so far removed from industrial centers as to be practically free from trade wastes, but oil pumped overboard by tankers unloading water ballast and from oil-burning steamships floats in large fields across these valuable beds, and its presence is already demonstrable on the bottom. If the condition continues, the industry in Delaware Bay is bound to follow that in New England and elsewhere.

6. A most striking example of the effects of oil may be seen at low tide on the shores of Staten Island. On a warm day, with consequent increased oxidation, soft clams (*Mya*) may be seen coming up to the surface of the flats by the thousands, dying soon after reaching the top. The surface of the flats is covered by a heavy film of oil, while the bodies of the animals reek with it. This region, however, receives industrial wastes, and hence is open to more than one interpretation, although there is no doubt in my own mind that oil is the chief cause of the destruction evident.

At Baltimore the writers were given the impression that harbor conditions were formerly so bad that the fishing industry was very badly handicapped. Now, however, the trouble is not so serious. Even at the present time it is necessary to go a considerable distance down the bay before it is possible to catch fish and other sea food in large quantities.

<sup>7</sup> Mitchell, P. H.: The Effect of Water-Gas Tar on Oysters. Bull., U. S. Bur. of Fish., Vol. XXXII, 1912 (1914), pp. 199-206. B. F. Doc. No. 786. Washington.

The conservation commission of Maryland, in reporting upon the pollution of navigable waters and the effect on fishes of Chesapeake Bay, states in part:

The effect of oil pollution in Chesapeake Bay, if allowed to continue as it has in some of the northern waters, would destroy our valuable fishery industries entirely as well as kill and drive away the wild fowl.

A most interesting condition was found at Brunswick, Ga., where a terrapin farm is located on a small creek not far distant from the plant of a large oil refining company. The situation of the terrapin farm is such that if any oil is spilled at the dock of the refinery it is very likely to be washed up into the terrapin farm at high tide through one or more of the small creeks emptying into Turtle River. On the day of the writers' visit a hardly perceptible trace of oil was visible in the water of the terrapin farm, but no indications of oil whatever were noticed on any of the wooden structures or on the turtles themselves. The investigators were informed that no fault could be found with present conditions in this location so far as the breeding of turtles is concerned. There appeared to have been no recent complaints from oystermen, and oysters grow freely in all the waters near Brunswick.

At Pensacola it was reported that the fishing industry and oyster beds have been harmed by oil pollution, and at Mobile complaints have been received from duck hunters. These complaints from wild game associations were to the effect that the fowl were covered with oil and unable to fly and at times many of the birds were found dead. The fishing industry of New Orleans has complained to the municipal authorities regarding oil pollution. In the Houston ship channel the absence of marine life is undoubtedly due not merely to the presence of large quantities of oil but also to the fact that the water in this stream is unusually warm. This results from the conditions prevailing in the industrial plants of this locality.

A carefully prepared report was submitted to the authors by Dr. David L. Belding, biologist of the division of fisheries and game, Massachusetts State department of conservation. Certain parts of the report have been used in the preceding pages of this paper. Other portions are given here:

During the past two years numerous complaints of oil-waste pollution along our shores, particularly as to its damaging effect upon wild fowl, have been received. Observations by this department have disclosed not only a marked increase in this type of pollution but also a widespread destruction of water fowl, especially during the cold weather. \* \* \*

Our attention was first called to the destructive action of this material on birds by the distressing plight of the swans on the Charles River in the winter of 1920-21, which was mentioned in last year's annual report. The metropolitan park commission requested the privilege of killing these swans, which had become so covered with black tarry oil that they had become helpless and starving in the cold weather. A post-mortem examination was made on two of these birds in an effort to determine the effect of the oil.

In response to a request of this division that all birds found dead under these circumstances be forwarded to the laboratory, pathological examinations were made on murrelets, auklets, grebes, and ducks during the winter. In spite of the fact that certain specimens were so completely covered with oil as to make examination impossible, and in others post-mortem changes rendered examination difficult, enough information was obtained to warrant certain conclusions as to the action of the oil wastes.

The birds, either in walking on the flats or resting on the oil-covered waters or tide pools, come into direct contact with the material, which tenaciously

sticks to their legs, wings, and the undersides of the body. As the bird endeavors to remove the clinging material its neck, head, and beak become more or less contaminated with the tarry material. The feathers are matted together, and when this occurs with the wings the bird becomes helpless. Even by the time the material has to any extent covered the feathers of the birds they have more or less reached this state. They find it impossible to fly, or at least fly in a normal manner, and can only walk or roll over the flats.

At the autopsy practically all the birds showed a similar condition, and a composite description of the findings may suffice for all.

Externally the birds are covered to a greater or less extent with a black, sticky, tarry oil, apparently a closely related product to crude petroleum. The material is incrustated upon legs, feet, and wings, and the feathers on the undersurface of the body are usually completely covered and matted together with the oil, while patches of the same material are present on the neck and back; as a rule the head and beak are also covered through the attempts of the bird to preen itself. The oil not only causes an adhesion of the feathers but penetrates to the skin at times, evidently causing a slight irritation.

\* \* \*

The matting of the wing feathers gives an effect similar to slipping, thus preventing normal flight dependent upon the extent of the involvement. With a tumbling, irregular flight the bird is more likely to become more extensively contaminated with the oil.

Associated with the question of flight and movement is that of obtaining food. In most of the birds examined the stomachs were empty, and in a few instances there was evidence of starvation, indicating that the birds were unable to obtain the food necessary for existence. However, it would seem that death occurred before or during the early stages of starvation, and that lack of food was probably only a contributing factor.

The internal organs were unaffected by disease and showed post-mortem changes. No evidence of pneumonia was found in any specimen.

The temperature of birds is slightly higher than that of man and is maintained through the air sacs and feathers. The latter are especially valuable in conserving body heat, and birds, if deprived of this covering, would be unable to maintain a normal body temperature in cold weather. The matting together of the feathers deprives them to some extent of their heat-protecting function and makes the birds more readily susceptible to severe weather.

No distinction was noted between the species of water fowl which frequent the oil-covered flats and shores. All seemed to be equally incapacitated. Small birds, however, are more likely to receive a relatively greater covering of oil and therefore may perish sooner than the larger ones.

#### CONCLUSION

Marine life and aquatic birds along the Atlantic and Gulf coasts have suffered seriously from pollution of waters by petroleum oil, but other industrial wastes are undoubtedly responsible for much of the damage done. This is a serious problem, primarily because of the vital importance of aquatic life as a source of food. Oil pollution is detrimental to shellfish by destroying the larval forms and rendering the adult mollusks and finny fish unfit for food. It causes considerable destruction of fowl, rendering the birds helpless through its mechanical action on the feathers.







