# DANGER TO FISHERIES FROM OIL AND TAR POLLUTION OF WATERS.[1]

By J. S. GUTSELL,
*Scientific Assistant, U. S. Bureau of Fisheries.*

Recently the casting of oil on already sorely troubled waters has increased at such a rate, has been accused as the source of so many ills of fishermen and shell fishermen and even of ornithologists, and has become such an obvious nuisance, that a considerable realization of the extent of the contamination and a sense of the possible evil effects have been aroused. So great is the discharge of oils of various sorts that in this country it has been proposed to skim off the oil from some harbor waters and make it available by proper treatment. In Switzerland a patent has been taken out for the recovery of oils from backwaters. It is very desirable, therefore, to present a brief review of the information available regarding the extent and nature of oil and oil-like pollutions with consideration of the possibilities of danger therefrom.

## SOURCES OF POLLUTION.

Danger of fatal contamination from the poisonous substances seems to lie chiefly in the gas plants and petroleum distilleries, which on one occasion or another, if not regularly, find it convenient to let certain products drain into the nearest body of water; in tankers and oil-engined craft, which are able to use tar, tar oils, and a great variety of petroleum distillates; in oil-burning steamships; and in the washings of oils and tars from roads.

Gas houses and oil refineries are located on all sorts of bodies of water larger than brooks. In smaller streams, and particularly in those inhabited by salmonids, discharges are doubtless frequently fatal to fish life and quite ruinous to the fish value of the water. In larger bodies the actual destruction of fish is apt to be small or incident to exceptional discharges, and the chief harm probably will come from the uninhabitability of the water, especially if this means the rendering unfit of a spawning ground or the forming of a barrier thereto as for salmon or shad.

In streams large enough for steamers, and in all larger bodies of water, there are added to the contributions from gas houses and refineries those from tankers and other ships, and the dangers to fishes from poisoning or coating of gills are correspondingly increased. These larger navigable bodies may be spawning grounds and are almost sure to be gateways to what should be spawning grounds. The danger here, therefore, of keeping fish away from the spawning

[1] Appendix VII to the Report of the U. S. Commissioner of Fisheries for 1921. B. F. Doc. 910.

grounds is far greater than the danger of destruction. It has been charged, but apparently not specifically established, that fish in harbors and the lower stretches of rivers have been killed by the dumping of oil from tankers. All of these vessels must clean out their tanks before they refill them and are prone to do so in harbor or as near there as may be.

Well out at sea and in the larger bays the only source of considerable oil pollution seems to lie in the shipping, which, if it can not discharge in or near harbors, will do so at sea. Moreover, it seems clearly established that great oil films do form at sea. Huge patches have frequently been observed, and Collinge reports that sea birds have been found dead and dying by hundreds off the English coast, their feathers saturated with oil. Death of sea birds from the same cause is reported from our Pacific coast.

Tar from freshly tarred roads may be washed bodily into gutters and thence into streams or other bodies of water. Apparently, however, the greatest danger of direct action from tarred roads is from the fact that under the various influences at work—presumably heat, the mechanical action of vehicles, and soluble action of oils—poisonous substances are yielded to road washings for a great length of time. Various people in England, as recorded especially in the (London) Fishing Gazette, have described instances or experiments which indicate the continued poisonous action of tarred roads. Richmond found that although an undisturbed tarred surface became innocuous in three weeks, washings from material chipped from a road which had not been tarred for approximately one year were fatal to fish. Tarred road washings appear to be noticeably destructive of fish and, largely through the destruction of food organisms, of fisheries, chiefly in streams not larger than small rivers and ponds, particularly trout waters. In well-developed country so fortunate as to possess salmon streams, tarred roads doubtless constitute a menace to the salmon fishery.

Oil from motor cars, etc., goes into small as well as large bodies of water and is of greatest volume at large towns.

## EFFECTS OF OIL POLLUTION.

Oil remains in part as a surface film on the water, and is probably in part emulsified and distributed in intermediate strata, while the heavier fractions are deposited on the bottom, where they persist for a long time. All parts are washed ashore to be deposited on the beaches and vegetation between tide marks.

This pollution may affect the fisheries in various ways: By actually killing or repelling the fish when they approach the shores in their migrations, at the only time when they can be caught; by sickening or killing bottom-dwelling species such as oysters; by killing floating eggs and the delicate larvæ which, swimming at or near the surface, are suffocated by the deposit of an impervious film on the gill surface; by destroying the minute surface plants and animals on which these larvæ and some of the adult fishes subsist; by diminishing the aeration of the water at the surface and thereby aggravating the deoxidizing effects of organic pollutions from municipal sewage and similar sources; by destroying spawning grounds; by killing the

shallow water vegetation which directly or indirectly furnishes fish food and shelter; and by impairment of the market value of fish through imparting to them an offensive taste.

## DIRECT TOXIC EFFECTS.

A great variety of tars and tar oils, either from coal or petroleum, have been shown to be highly poisonous. Butterfield and writers in the (London) Fishing Gazette and the Salmon and Trout Magazine, and Shelford and Thomas in this country (see bibliography) have reported various experiments which show that tar and tar oils are poisonous in great dilutions. Tars or tar oils result from distillations of coal, petroleum, woods, etc. These distillation products are very complex and varying in composition, but all may be assumed to contain some of the substances which, in very weak dilutions, have been shown to be highly poisonous to various fishes. Phenols and cresols (in dilutions of less than 100 parts per million) have been found quickly fatal by Butterfield and Shelford. Other constituents which are quickly fatal in the dilutions indicated are phenanthene and naphthalene (4 to 5 parts per million); xylene, toluene, benzene, and ethylene (22 to 65 parts per million); sulphur compounds, as hydrogen sulphide (5 parts per million), sulphur dioxide (16 parts per million); carbon bisulphide (100 parts per million); thiophene (27 parts per million); ammonia (7 parts per million); and ammonium salts and other nitrogenized compounds (some hundred parts per million); quinoline and isoquinoline (50 to 65 parts per million). The strengths given as quickly fatal are those which have caused death in one hour, or very little more, to sunfish (American) or gudgeon (European), fish which seem more than ordinarily resistant to poisons. It is stated (Seydel) that Russian investigators find hexahydrobenzoic acid ($C_6H_{11}CO.CH$), to be the essential poison of Russian petroleum, and that 4 to 16 parts per million were quickly fatal to a cyprinid and a percid.

The experiments of Thomas and others indicate that prolonged exposure to very much greater dilutions of these substances are fatal. Dilutions of various tars and crude distillates of petroleum, which required 66 or more parts per million for quick fatality, have proved fatal in strengths of from 13 to 33 parts per million in from 1 to 3 days. A great variety at 13 parts per million proved fatal in 3 days. One liquid tar waste at 2 parts per million killed sunfish (*Lepomis humilis*) in one day.

## MECHANICAL EFFECTS.

Certain petroleum products appear to contain no poisonous substances soluble in water and to have little direct effect when allowed to form a surface film, but when emulsified by agitation prove deadly. A high-boiling petroleum distillate and a light fuel oil were found by Thomas to be quite harmless, unless as aeration retarders, or unless emulsified, as by continued moderate agitation, when they coated the gill membranes of the fish and caused death by suffocation. Rushton found that by shaking up 1 part of benzine with 40,000 parts of water, a mixture was formed which killed fish in five minutes, apparently entirely from poisonous action.

Doubtless under the agitation of continued wave action many, if not all, oils and oily substances will emulsify or mix to a considerable extent and so coat the gills of fish or other forms, or have a poisonous effect which their insolubility would otherwise prevent. According to Weigelt, ulcerations and attacks of disease have been found to follow the irritating action of petroleum products.

The eggs of sea fishes which do not seek fresh, brackish, or shore waters in which to spawn differ from the eggs of all these and of fresh-water species in that they are typically floating. In many cases, at least, the larvæ for a time are also floating. This fact renders the possibility of grave danger to the great sea fisheries a very striking one, for it can scarcely be thought that eggs can hatch and young normally develop in a medium of oil. The eggs and larvæ of oysters and other shellfish are not surface floating, but are carried up and down by the current, sometimes to the surface. A special danger to them lies in the fact that both oil and larvæ (and eggs) are prone to collect in eddies.

## PREVENTION OF AERATION OF THE WATER.

The question of aeration prevention by an oil film is a very important one. Butterfield and Thomas have questioned considerable prevention, Butterfield on the supposition that mineral oil is similar to water in its oxygen absorption, and Thomas apparently on the theory that incomplete rather than complete films tend to form. There need be no question that extensive films do form. Furthermore it seems established by Adeney, especially in salt water and any water of considerable mineral content, that streaming, with the consequent distribution of the air saturated surface water, is largely dependent upon evaporation and increased density at the surface. If this is the case it must follow that an oil film, by preventing evaporation, greatly checks aeration. Danger from this seems chiefly to center in harbors where, because of general pollution, particularly sewage pollution, the oxygen consumption is greatest and where, because of gas plants and shipping and the great number of automobiles, the discharge of oil is also extreme. These are the same harbors which are the gateways to the great natural spawning areas of the anadromous fishes.

In connection with the prevention of aeration, oxygen loss by the absorption of dissolved oxygen, by fatty acids and other substances present in oils and tars, should be taken into consideration.

## DESTRUCTION OF FISH FOOD.

Indirect action of oils and tars may consist of poisonous action on food organisms. Prawns appear very susceptible to tar poisons, and in English streams it has appeared that tarred road washings are even more destructive of insect life than of trout directly. It can scarcely be doubted that the susceptibility of minute forms is at least of the same order as that of fish. With a number of microscopic forms, particularly diatoms, it is known that their susceptibility to a number of poisons is greater than that of fish (Whipple, Moore, and Kellerman). Destruction may, of course, be secondary,

as from lack of oxygen, or from the destruction or spoiling of emergent or littoral vegetation with an oil coating, particularly in tidal areas (by which means wild fowls may also greatly suffer), and the consequent loss of a productive habitat.

From gas houses, tarred roads, and refineries much of the contamination eventually finds its way to the bottom to render it more or less sterile according to thickness and completeness of the deposit and the constancy with which the deposit is maintained. Wadham indicates that he found apparently complete strata for each fresh tarring of road, and that it took two or more years for a trout brook to recover proper productivity of fish.

In some waters the basic fish food consists in part of air-breathing larvæ and pupæ of insects, which, if a layer of oil is present, as is well known, will be unable to come to the surface to breathe and so will be destroyed. Young of food fishes or the small fish on which food fishes feed will in consequence be deprived of an important source of food, and the productivity of the region will be correspondingly decreased. In 1920, through the Gulf States, Mr. Hildebrand found that Gambusia and Fundulus, which feed largely on such larvæ and pupæ, disappeared from oil-covered water. He took no special notes in regard to larger species, but believed they disappeared also, presumably because their food had disappeared.

## SUMMARY.

Three main sources of oil and tar pollution have been found: Road washings, carrying great quantities of lubricating oil; gas houses and oil refineries; tankers, oil burners, and oil-engined shipping. Tars, tar oils, and crude distillery products are found generally to be highly poisonous, whether in weak or great dilution. Some oils have been found to emulsify to a sufficient degree, with continued agitation, to coat the gills of fish and so produce death by suffocation. An oil film, through prevention or checking of aeration, is dangerous, particularly in busy harbors. The deleterious effect on spawning, by rendering spawning grounds unfit or inaccessible, is a grave danger arising from the pollution of harbors and streams. Another serious danger is found to lie in the possible effects on the diminution of the food supply. Through whatever means, it is an observed fact, according to Weigelt, that in Germany fish have completely disappeared from pools and ponds following the discharge of mineral oil into the water. In the sea a great danger is suggested by the fact that the eggs of sea fishes are typically floating, and that oil-burning and oil-engined shipping is greatly increasing.

Remedial measures may (now or in the future) be found: (1) In the recovery of oils from drainage water, as already has been proposed; (2) in the prevention of gas-house and refinery pollution, which prevention should be helped by the increased use of "wastes" in by-products; and (3) in prevention, by international arrangements, of the dumping of oil from ships in harbors or in the region of spawning grounds or special feeding areas.

## BIBLIOGRAPHY.


ADENEY, W. E.

1912. Report of W. E. Adeney. *In* Present sanitary condition of New York harbor and the degree of cleanness which is necessary and sufficient for the water. Report of the Metropolitan Sewerage Commission of New York, 1912, p. 80–121. Wynkoop Hallenbeck Crawford Co., New York.

ALLEN, E. J.

1914. Letter telling of deadly effects on swimming prawn of creosote oil in great dilutions. *In* Net curing by creosote. Fish Trades Gazette, Vol. 31, Feb. 28, 1914, p. 36. London.

BUTTERFIELD, W. J. A.

1912. The relation of modern road surfacing to fish life. The Surveyor, Vol. 41, Feb. 16, 1912, p. 277–284. London.

COKER, R. E.

1920. Progress in biological inquiries. Report of the Division of Scientific Inquiry for the fiscal year 1920. Appendix II, Report, U. S. Commissioner of Fisheries for 1920. Bureau of Fisheries Doc. No. 896. p. 23. Washington.

COLLINGE, WALTER E.

1921. The effects of oil from ships on certain sea birds. Nature, Vol. 106, Feb. 24, 1921, p. 830. London.

FISHING GAZETTE (THE). LONDON.

1910. Note by editor, R. B. Marston, containing letter from R. C. W. H. Butler telling of harmless leakage of a barrel of crude tar into trout ponds. The Fishing Gazette, Vol. LX, June 4, 1910, p. 508.

Note by editor quoting letter from Arthur J. Belcher (extracted from the Daily Mail of June 14) telling of the immediate destruction of hundreds of trout following the washing of tar from a freshly tarred road into trout brook. Ibid., Vol. LX, June 18, 1910, p. 559.

Letter from A. R. Peart telling of experiments showing deadliness to fish life of water which has been in contact with fresh crude tar; also pointing out that road washings may be expected to reach stream while it is still shrunken by preceding drought. Ibid., Vol. LX, June 25, p. 607.

Account by Field of destruction of fish and vegetation following tarring of roads, and of finding a high tar content in road washings. Ibid., Vol. LXI, July 23, 1910, p. 99–100.

Letter (anon.) telling of experiments showing deadliness to trout at various dilutions of water which had been in contact with coal tar. Ibid., Vol. LXI, July 30, 1910, p. 125–126.

Note by editor containing letter from "Elfa" telling of development of fungoid growth following the washing of tar from road into stream. Ibid., Vol. LXI, Aug. 6, 1910, p. 144.

Note by editor quoting note from Percy Wadham on the road-tarring question. Ibid., Vol. LXI, Aug. 20, 1910, p. 188.

Investigation of an epidemic of fish poisoning by tar at Drinkwater Park, Manchester, by E. J. Sidebotham and A. Sellers. (*From* Archives of the Public Health Laboratory of the University of Manchester, Vol. I, 1906.) Ibid., Vol. LXI, Aug. 27, 1910, pp. 210–211.

1911. Note by editor quoting account from Dundee Courier of Aug. 5, 1911, of the washing by thunder storm of tar from freshly tarred road in the River Fary, the killing of many scores of fine trout, and the ruining of the fishing below. Ibid., Vol. LXIII, Aug. 12, 1911, p. 163.

Letter from F. I. C., one technically informed, telling of amounts of naphthaline and phenol bodies allowed in road tar and maintaining that treatment which renders tar innocuous spoils it for road work. Ibid., Vol. LXIII, Aug. 26, 1911, p. 233.

1912. Note by editor quoting letter from S. Jaffé telling of destruction of fish and small and microscopic forms by leakage of 2,200 cubic yards of tar and by-products and of over £1,600 paid in damages; and letter from Karl Heintz to the effect that it is illegal in Bavaria (or all Germany?) to construct drains from tarred roads into streams. Ibid., Vol. LXV, Dec. 21, 1912, p. 582.

1913. Note by editor quoting extract from Isle of Wight County Press telling of settling with F. T. Mew, of Carrisbrooke, Isle of Wight, for £325 for damage to fishery by tarred-road washings. Ibid., Vol. LXVI, Mar. 15, 1913, p. 66.

Letter from Percy Wadham on the difficulty of determining the real danger from tar poisoning by laboratory experimentation. Ibid., Vol. LXVI, May 24, 1913, p. 480.

1914. Note by editor quoting letter from F. Napier Sutton on the effect of leakage from gas works on a fishery. Ibid., Vol. LXVIII, Jan. 3, 1914, p. 2.

1917. Note by editor quoting letter from Percy Wadham telling of lasting poisonousness of tar on roads and of formation of tarry strata on pond bottoms, etc. Ibid., Vol. LXXIV, Feb. 24, 1917, p. 100.

1921. Report of address by J. A. Simpson delivered at Nottingham January 12 before "An Alliance for Prevention of River Pollution," telling of fining of Derbyshire County Council and of damages obtained by riparian owners for destruction of fishing by tarred-road washings. Ibid., Vol. LXXXII, Jan. 22, 1921, p. 45.

Note by editor to the effect that the Joint Committee of Ministry of Agriculture and Fisheries and the Ministry of Transport have been unable to find a safe tar; refers to an account by Dr. Smith, U. S. Commissioner Fisheries, of experiments to find a safe tar without success. Ibid., Vol. LXXXII, Feb. 26, 1921, p. 117.

FORBES, S. A.

1894. Report on effect of oil-well and gas-house waste on fish and fisheries of the Wabash River. *In* House of Representatives Miscellaneous Document No. 196, 53d Congress, 2d Session, p. 2–5. Also *quoted by* Richard Rathbun *in* Report of Commissioner, U. S. Commission of Fish and Fisheries for 1894 (1896), p. 109–112. Washington.

HILDEBRAND, SAMUEL F.

1921. Top minnows in relation to malaria control, with notes on their habits and distribution. Public Health Bulletin No. 114, U. S. Public Health Service, Treasury Department, p. 17. Washington.

HOME, DAVID MILNE

1883. Salmon and salmon fisheries. International fisheries exhibition. London, 1883. Conference on July 17, 1883. The Fisheries Exhibition Literature, Vol. VI, Conferences, Part III, 58 p. William Clowes and Sons, Limited, London.

LENZING, C. W.

1917. Effect of gas-house waste on the biochemical oxydation of sewage. University of Illinois Bulletin, Vol. 15, No. 11, Water Survey Series No. 15, Chemical and Biological Survey of the Waters of Illinois, Report for . . . 1916, p. 168–174. Urbana.

MCDONALD, MARSHALL

1885. Report on the pollution of the Potomac River by the discharge of waste products from gas manufacture. Bulletin, U. S. Fish Commission, Vol. V, 1885, p. 125–126. Washington.

Effect of waste products from Page's ammoniacal works upon young shad fry. Ibid., p. 313–314.

MARSH, MILLARD CALEB

1907. The effect of some industrial wastes on fishes. (*Reprint from* The Potomac River Basin, U. S. Geological Survey, Water Supply and Irrigation Paper No. 192, p. 337–348.) U. S. Fisheries Doc. No. 619. Washington.

MOORE, GEORGE T., and KARL F. KELLERMAN

1905. Copper as an algicide and disinfectant in water supplies. Bulletin 76, Bureau of Plant Industry, U. S. Department of Agriculture, 55 p. Washington.

MOSELY, MARTIN E.

1920. Trout fishing and road tarring. Salmon and Trout Magazine, No. 21, March 1920, p. 70–73. London.

RICHMOND, F. G.
1914. Some questions of tar. Salmon and Trout Magazine, No. 9, December, 1914, p. 35–42. London.
RUSHTON, W.
1921. Biological notes. Salmon and Trout Magazine, No. 25, April, 1921, p. 114. London.
SALMON AND TROUT MAGAZINE. LONDON.
1916. Road tarring. Salmon and Trout Magazine, No. 14, October, 1916, *in* Editorial Notes, p. 6–7.
1919. The road-tarring question. Ibid., No. 18, April, 1919, p. 51–57.
Road tarring. Ibid., No. 20, November, 1919, *in* Editorial Notes, p. 7.
1920. Road tarring and fisheries.—Work of the Joint Committee. Ibid., No. 23, September, 1920, *in* Editorial Notes, p. 9–10.
SCIENTIFIC AMERICAN.
1921. When oil stops the shifting sands. Scientific American, Vol. CXXV, No. 5, July 30, 1921, p. 83. Munn & Co., New York.
SEYDEL, E.
1914. Über die Wirkung von Mineralölen auf Fischwasser. Mitteilungen des Fischereivereins, f. d. Provinz Brandenburg, Bd. 5, p. 26–28. Reviewed *in* Wasser U. Abwasser, Bd. 7, p. 49.
SHELFORD, VICTOR E.
1917. An experimental study of the effects of gas waste upon fishes, with especial reference to stream pollution. Bulletin, Illinois State Laboratory of Natural History, Vol. XI, Art. VI, p. 381–412. Urbana.
SHIPLEY, A. E.
1921. Oil from ships. Effects of discharge in the sea. Suffering fisheries. Letter to the editor, London Times, January 21, 1921, p. 6.
THOMAS, ADRIAN.
——. A study of the effects of certain oils, tars, and creosotes upon brook trout (*Salvelinus fontinalis*). Manuscript.
TOWNSEND, CHARLES H.
1908. Pollution of streams—an appeal to anglers. Reprinted from the twelfth annual report of the New York Zoological Society, 1908, 7 p. New York.
WARD, HENRY B.
1919. Stream pollution in New York State. A preliminary investigation of the problem from the standpoint of the biologist. Made in July and August, 1918. State of New York Conservation Commission, Albany. J. B. Lyon & Co., Printers.
WEIGELT, C.
1904. L'assainissement et le rapeuplement des rivières. Traduction française de C. Julin. (Extrait du tome LXIV, Mémoires couronnés et autres Mémoires, publiés par l'Académie royale de Belgique, 1903.) 668 p. Carl Heymanns Verlag, Berlin.
WHIPPLE, GEORGE CHANDLER.
1914. The microscopy of drinking water. 409 p. John Wiley & Sons, Inc., New York.
WILSON, H. MACLEAN and H. T. CALVERT.
1913. A text-book on trade waste waters: their nature and disposal. XII, 340 p. C. Griffin & Co., Limited, London.

○