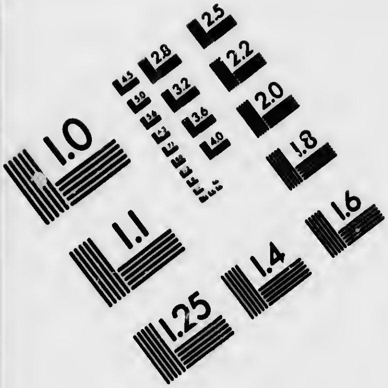
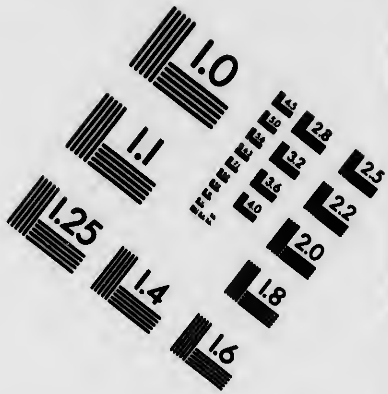
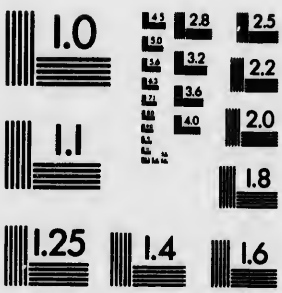
IMAGE EVALUATION TEST TARGET (MT-3)

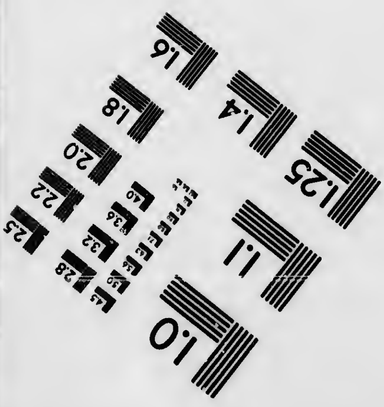






150mm

6"



APPLIED IMAGE . Inc
1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989

Technical and Bibliographic Notes / Notes techniques et bibliographiques

The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

- ☐ Coloured covers/ Couverture de couleur
- ☐ Covers damaged/ Couverture endommagée
- ☐ Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- ☐ Cover title missing/ Le titre de couverture manque
- ☐ Coloured maps/ Cartes géographiques en couleur
- ☐ Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- ☐ Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- ☐ Bound with other material/ Relié avec d'autres documents
- ☐ Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure
- ☐ Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

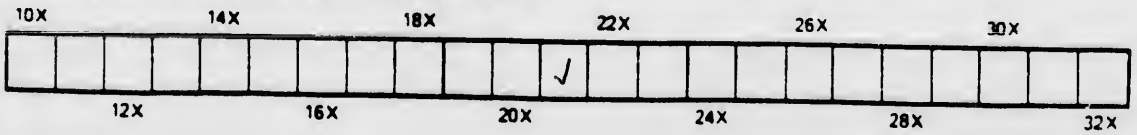
- ☐ Coloured pages/ Pages de couleur
- ☐ Pages damaged/ Pages endommagées
- ☐ Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- ☑ Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- ☐ Pages detached/ Pages détachées
- ☑ Showthrough/ Transparence
- ☑ Quality of print varies/ Qualité inégale de l'impression
- ☐ Continuous pagination/ Pagination continue
- ☐ Includes index(es)/ Comprend un (des) index

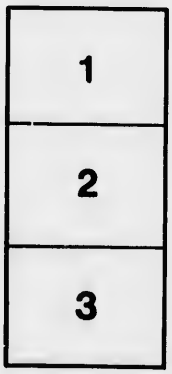
Title on header taken from:/ Le titre de l'en-tête provient:

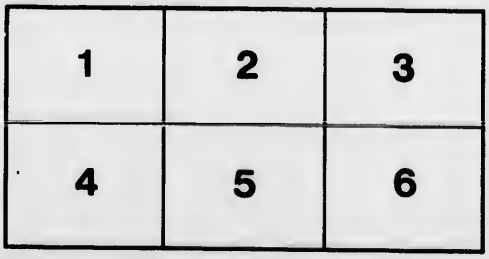
- ☐ Title page of issue/ Page de titre de la livraison
- ☐ Caption of issue/ Titre de départ de la livraison
- ☐ Masthead/ Générique (périodiques) de la livraison

☐ Additional comments:/ Commentaires supplémentaires:

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.







Pisciculture 6

SPECIAL

APPENDED REPORTS

BY

PROFESSOR E. E. PRINCE

Dominion Commissioner of Fisheries

1. WATER POLLUTIONS AS AFFECTING FISHERIES.
2. NEGLECTED STRUCTURAL FEATURES IN YOUNG FRY.
3. THE OBJECT OF A CLOSE TIME FOR FISH.

1899

SPECIAL REPORTS

CONTENTS

I.—Water Pollutions as affecting Fisheries.

I.—Water Pollutions, &c.—*Con.*

I.—Water Pollutions, &c.—*Con.*

II.—Neglected Structural Features in young fry.

III.—The object of a close-time for fish.

SPECIAL APPENDED REPORTS

I

WATER-POLLUTIONS AS AFFECTING FISHERIES

BY PROFESSOR PRINCE, COMMISSIONER OF FISHERIES, OTTAWA.

Fishery legislation in different countries bears testimony to the importance universally attached to the evil effects of water-pollution upon fish life. Clauses are, as a rule, found embodied in codes of fishery regulations, with the object of directly or indirectly preventing the poisoning and polluting of waters inhabited by fishes. Yet the true relations of the various polluting agencies to the conditions of fish-life are little understood generally, and the nature of diverse injurious influences, the different modes in which foreign matters affect the finny tribes, that is to say, the comparative harmfulness or harmlessness of what are known as deleterious matters, have never been thoroughly and exhaustively tested and investigated. There can be little doubt that many ideas which are prevalent upon this subject have little basis in fact, and it is unquestionable that many well-meant attempts to cope with the supposed evils of river- and lake-pollution have been made without adequate knowledge. The object, of course, is to prevent the wasteful and wholesale destruction of fish, whether by design, or by negligent poisoning of waters: but the question remains to be decided as to what agencies, usually called pollutions, are really harmful to fishes and harmful in such a degree that serious and extensive destruction results. In England the existing laws are extremely severe upon this matter, but no doubt cases continually occur in which it is difficult, if not impossible, to prove clearly that the fisheries are injured, and, as Sir Frederick Pollock has pointed out, offenders may evade the law, or at any rate escape the penalties, if steps have been taken to render innocuous the alleged deleterious substances which have caused the pollution. As the authority named says:

"Dynamite or other explosives must not be used to catch or destroy fish in a public fishery in any part of the United Kingdom, or in the adjacent seas within a marine league of the coast, nor in a private fishery in England, on pain of fine up to £20 or imprisonment, which may be with hard labour, up to two months. The poisoning of any salmon rivers, as well as of any waters where there is a private right of fishery, with "any lime or other noxious material," in order to destroy fish, is an offence punishable with penal servitude up to seven years. Pollution of salmon rivers "to such an extent as to cause the waters to poison or kill fish" (though not intended to have that effect) is punishable by fine on an increasing scale, ending in £20 a day after a third conviction. But the party may escape these penalties, if his act in sending refuse, or whatever it may be, into the river, is not otherwise unlawful, and he can show that, being thus in the exercise of his right, 'he has used the best practicable means, within a reasonable cost, to render harmless the liquid or solid matter so permitted to flow or to be put into waters.' Probably it is not difficult to satisfy justices of this in a manufacturing district; again, if the stuff poured into the river is so noxious that there are not any practicable means at all of rendering it harmless, it is by no means clear whether any penalty is incurred. The person complained of may also, if a decision against him would cost him more than £100, require an action to be brought in the High Court of

justice to settle the question whether he has used the "best practicable means," and it is not hard to guess what, on such a question, the bias of jurymen in a manufacturing country is likely to be."

Briefly stated, pollutions, so far as rivers, lakes and tidal waters are concerned, may, in their nature and effects, be physically or mechanically deleterious, like sawdust or the mud and gravel resulting from hydraulic mining, or they may be chemically injurious, and in a larger or less degree poisonous, like lime, drugs, waste of dye works, pulp and paper mills, etc., or they may be physiologically deleterious, but not toxic in the gravest sense, inducing unhealthy conditions in the fish, such as appears to result from putrescent matter, sewage, decaying animal and vegetable substances, etc. The Canadian Fisheries Act aims to include all these, and subjects to specified penalties every person who causes or knowingly permits to pass into, or puts or knowingly permits to be put lime, chemical substances or drugs, poisonous matter, dead or decaying fish, or remnants thereof, mill rubbish or sawdust or any other deleterious substance, in any water frequented by any of the kinds of fish mentioned in the Act, Chap. 95, 1886, s. 15, ss. 2, amended by chap. 51, 57-58 Vict., s. 6.

It is not necessary to prove the deadly character of the polluting substances. The provision does not, however, apply if it can be shown that the fish inhabiting polluted waters are of inferior kinds, not mentioned in the Act or regulations under it. Thus, injury to eels or fresh-water ling is not included, but the prohibition applies in waters inhabited by salmon, trout, etc., and it is interesting to note that it embraces the triple division of injurious substances, to which I have alluded, for lime, chemical substances and drugs belong to the essentially toxic or poisonous group, sawdust is really a physically deleterious agent, and the other undesirable substances may be said to include pollutions which affect fish life in ways differing from those directly destructive to life, or physically noxious and morbid in effect.

For many years it was thought that the deadly fungus, commonly called salmon disease (*Saprolegnia*), was due to river pollutions, which were supposed to encourage if not to originate the aquatic saprophyte. Researches have shown that this is not the case, and outbreaks of salmon disease have repeatedly occurred in waters in which there was no special pollution whatever. Not only so, but the detested fungus frequently appears first in the upper waters, and it is indisputable that salmon on entering rivers from the sea are without exception in a healthy condition. Water in which lime is present in appreciable quantities appears very favourable to the growth and development of fish fungus, but the plant cannot originate unless the spores are there either as minute oospores, or as zoospores, which are really a very early stage of the fungus growth. The spore germs multiply and disperse so rapidly that the infection of every fish in a salmon river may be effected in a comparatively short period—healthy fish as well as weakly and injured fish, though the latter are attacked more readily.

But deleterious substances differ not only in themselves, so far as their direct influence upon fish life is concerned, they also vary in their injurious potency according to the circumstances and the places where introduced. Substances may be seriously harmful in a slow-running river, which are comparatively harmless in a swift stream, and I cannot fully agree with the view of certain eminent authorities that it is little or no advantage to keep pure and free from pollution the upper waters if the lower waters and estuaries are allowed to be filled with impurities. Indeed there is force in the contention of Boccius that 'the true cause of the depletion of rivers originated and begun in the destruction of the egg, and not in the fish, when once brought into being.' The experiments of Mr. A. Hansen, on the Norwegian River Soli, in 1872, prove that unfavourable conditions in the lower waters are of far less moment than they are in the shallow headwaters, as Prof. Rasch has pointed out in his paper entitled 'Is sawdust an obstacle to the ascent of fish?' The estuaries of certain rivers on this continent are polluted with saw-mill waste, etc., yet the injury done does not compare with that which would follow the pouring of saw dust, edgings, etc., from the mills into the upper waters. Such waste would cover the spawning areas, where the eggs are deposited and where the fry pass their first days. The Fraser River, B.C., has for twenty years been polluted to a frightful extent with

the refuse and offal from dozens of large salmon canneries. This offal composed of heads, fins, tails, entrails and fragments, which it does not pay to utilize, is dumped into the water near each cannery. At first it sinks, and then it rises to the surface, chiefly on account of the expansion of the gases formed in the swim-bladders and intestines. A prominent New Westminster fisherman, who gave evidence before the British Columbia Fishery Commission, 1892, (printed at Ottawa, 1893), said: 'I think at the mouth of the river its effect is very bad. Down there it floats and lines the banks and gets foul of the nets—heads, guts, etc. It destroys the nets more than the salmon do and makes the water filthy—not fit for use unless cooked.' Many fishermen on the Fraser River hold these views, and claim that it deters the fish from coming in. But it is by no means established that it is detrimental to the incoming schools of fish. The Joint Fisheries Commission, 1896, indeed reported as follows on this question:—'The cannery people everywhere are confident that no harm results from their method of disposing of the offal, unless it be in certain restricted areas where the eddies cause its retention for a time. During the greater part of the canning season the volume of water in the Fraser River is large, its temperature is low and the current strong. The offal in a fresh condition is said to sink at once and to disappear. The inhabitants, generally, along the river oppose the practice on the ground that it is injurious to health, from which standpoint, however, the question is not of international significance. With respect to the open waters of the Sound, we have heard of no complaints regarding this matter, although some of the offal is known to wash ashore in places. No evidence has been obtained which shows that the throwing in of the offal has had a pernicious effect upon the movements or the abundance of the salmon. If such an effect has actually been produced, as may be the case it has not, up to the present time, made itself sufficiently manifest to bring it within the scope of observation. We are led, however, to deprecate the continuance of the practice for local reasons at least, and would urge further experiments looking to the utilization of the offal as an incentive to its retention on land.'

In the cod and mackerel fisheries, as well as in the lobster canning industry, great quantities of offal are as a rule accumulated, which are dumped into the sea close to the places where the fishing or the canning is carried on. So vast was the quantity thrown into the inshore waters along the Labrador coast and the north shore of the Gulf of St. Lawrence that a special prohibition was enacted to prevent the abuse which, it was claimed, was driving the schools of cod away. Along the shore referred to the cod come in very close in immense schools, and are taken to a large extent in fixed traps or pounds. A similar injury was said to have been done to the schools of mackerel off the Atlantic coast of Canada, especially by United States mackerel schooners, which cleaned and split their fish on board and threw over the 'gurry.' The harm done by lobster canneries has no doubt been exaggerated, as the quantity of foul refuse is limited as compared with the 'gurry' from fish curing operations.

Taking up the question of water pollution as produced by agents which are essentially physical or mechanical in their effects, and which do not in any degree, or in a very small degree, act as chemical poisons, or as physiologically harmful, it is doubtful to what precise extent such physical agents, say, suspended particles of sawdust, or gravel, injuriously, affect fishes in the adult condition. It is true a widespread impression prevails that such suspended foreign matters are most harmful. This impression has little accurate or scientific basis, but it has been stated and restated with the utmost confidence. Thus in a report of this department published in 1889, Part II, p. 12, the following emphatic expression of opinion appeared:

The poisonous effects of sawdust, when allowed to pass into rivers and streams, are so manifold and self-evident to the rational or practical observer, that it would appear almost needless, in the present enlightened state of the world, to require any special pleas or arguments to convince even the most sceptical person of its disastrous workings upon all aquatic life, of an animal or vegetable character, found in the tidal, lacustrine or fluvial waters of any country. Wherever mill-dams have been built across streams, and where sawdust, mill rubbish and other deleterious substances have been cast into the water from saw-mills and other manufactories,

fish-life and vegetation of all kinds have been greatly lessened, and in many instances wholly destroyed. This is particularly noticeable amongst the higher order of fishes, especially the salmon family, which are largely of a migratory nature, many of them ascending rivers and other streams for breeding purposes. These waters are usually of the purest, coldest and most limpid description, and therefore best adapted for the propagation of the salmon species. These fish at the time of the first settlements of Canada were found frequenting almost every river and stream emptying into the sea, and the great lakes also. So plentiful were they in many of our waters, before the lumbering industry took such a strong hold in the erection of dams and saw-mills, with the consequent injurious effects from them upon fish-life that fish of all kinds were in great abundance. They were freely used by the inhabitants generally for domestic purposes, and also produced a large amount of traffic and commercial wealth for the country. But as the saw-mills and mill-dams increased in numbers with greater capacity for their work, the mill-dams formed impassable barriers to the ascent of salmon and other fishes to their natural spawning grounds above—and then the hurtful and pernicious effects arising from the sawdust and mill rubbish being constantly cast into the streams poisoned the spawning beds below, and stayed the growth of all vegetation, thus driving away insect life, which is the principal sustenance for fish in their younger stages of existence. As this improvident work of the mills increased in magnitude, so did the yield of all kinds of fish decrease in these waters until it has been found in some cases that, after stripping the neighbourhoods of all lumbering material and destroying all fish-life, these mills have gone into ruin and decay, leaving sorrowful mementos only of their destructive workings in the waters of the country for the inhabitants who follow after. It is, therefore, of the greatest importance that any law which provides 'that sawdust or mill rubbish shall not be drifted or thrown into any streams or other waters frequented by fish, should be maintained and strictly enforced wherever the continuance of fish life is held to be of any benefit to the people. There are yet to be found sufficient numbers of fish, natives of the rivers and other waters, left, from which, by proper protection and good husbandry, an immense supply of fish food and commercial wealth would be readily obtained for the general benefit of the inhabitants of the several sections of the country. Sawdust, as previously stated, is manifold in its range of destruction when allowed to be cast into waters to which fish are indigenous, or where animal or vegetable life is to be sustained. It is an artificial product, alien to and engendering latent diseases of various kinds, with fatal results in all waters where fish life exists.'

That mill-dams and other obstructions seriously damage rivers and waters resorted to by fish cannot be questioned; but this damage would be done even though no sawdust whatever were thrown in them. Further, the contention that sawdust in the streams is offensive to the fish and has caused them to forsake their accustomed haunts, as Dr. Milner some years ago claimed, has never been proved, whereas there is abundant proof that most fishes are not deterred by the floating particles of saw-mill waste. In the New Hampshire Fishery Commissioner's Report for 1885, it is asserted that harm arises from 'the sawdust getting into the gills of the parent-fish'; but there is no case on record of salmon, or shad, or any other healthy adult fish, being found choked with sawdust or in any way fatally injured by the floating particles.

When I accompanied for a time in 1893 the International Commissioners, at the request of the Hon. the Minister of Marine and Fisheries, nothing astonished me more than the extent and serious nature of the sawdust pollution on certains tributaries of the St. John River in New Brunswick. The main river is largely subject to this pollution, but not in any degree to the extent that obtains on some of the tributary rivers. The Aroostook River, which for over 100 miles runs through the State of Maine, and only during the last four miles of its course passes through New Brunswick is a flagrant example. Some of the largest lumber mills in that part of the country occur on its banks, and the lumber industry is of immense extent. Nothing could be worse than the condition of this fine salmon river, and a common opinion prevailed that no salmon could or would ascend it. Yet at the time of the commissioners' visit quite a number of salmon had been noticed a little above Cariboo and a

fish-ladder had been provided to enable them to ascend an impassable dam at that point. Fairly large catches of salmon have been made in recent years, notwithstanding the view common a few years ago that sawdust pollution had driven them all away. This pollution is excessive, and, 'except for the small amount consumed by the steam mills, the river is made the common dumping ground for all the waste of this character," said the Commissioners 'as the most convenient way of disposing of it, no regard being had to the public interests which are thus impaired.' Robust species like the salmon, sea-trout, brook trout, striped bass might not suffer harm, provided, as they are, with capacious mouth and branchial cavities: but it might be different with members of the herring tribe (Clupeidae), the shad, gaspereau, etc., with their small mouth-aperture studded with rows of erect teeth on both jaws, on the palatine bones, the vomer and the tongue, and provided with small rod-like gill-rakers, all combining to form a cage or sifting apparatus for retaining small shrimps and crustacea upon which they so largely subsist, for these fishes might apparently be readily choked by particles of sawdust clogging up their delicate oral structures. I have not been able to find, however, that any shad, gaspereaux or other migratory members of the herring family have been found dead in quantities on account of sawdust suffocation. In other words, so far as our present knowledge goes sawdust pollution if it does not affect the upper waters, the shallow spawning and hatching grounds, appears to do little harm to the adult fish in their passage up from the sea.

This opinion I find on reference to the Report of the United States Fish Commission Part VI, 1878, was expressed by Dr. H. Rasch when treating of the sawdust question in Norway. Professor Rasch is very explicit in the statement of his views, and does not shrink from claiming that 'while it is asserted that the sawdust introduced into the river from the saw-mills causes the salmon coming from the sea either to forsake its foster stream because of meeting the sawdust, to seek another river not polluted, or else, when the fish attempts to pass through the areas quite filled with sawdust, then this, by fixing itself in the gill-openings or between the gills, causes its death, yet later experience seems to entitle us to the assumption that sawdust neither causes the salmon to forsake its native stream nor produces any great mortality among the ascending fishes. The hurtfulness of the sawdust to the reproduction of the salmon is not so direct, but is exceedingly great in this, that it partly limits and partly destroys the spawning-grounds of the river.'

He goes on to give certain details of an experiment upon the effect of sawdust on young salmon transplanted from one river to another which was much polluted with this waste product. He says:—

'That young salmon bred from a race of salmon which has its own river, when they are set free in a strange river and one which is in an unusual degree polluted by sawdust, will not be prevented by this circumstance from returning to this last-named stream after their wandering in the sea, one had a convincing illustration in the great experiment instituted last year by Director A. Hanson. In olden times the salmon-shoal which had its spawning-place in Soli River could ascend to it through the then passable Soli cataract, but when they, for the sake of the increased mill-business, erected above the cataract a dam so high that the salmon could not ascend to their spawning-grounds, this salmon shoal gradually died out entirely.'

The conclusion to be drawn from such statements and experiments is this, that the gravest cause of the decline in most salmon rivers is due less to sawdust pollution which except in the breeding grounds, has principally a merely mechanical or physical effect, than to the mill-dams and other obstructions which prevent the parent fish from ascending and successfully depositing their eggs. If access is free to upper portions of salmon rivers usually less affected by sawdust and mill waste, the parent fish are not readily deterred by the pollution of the lower reaches of such rivers. The ruthless destruction of spawning fish by poachers and reckless netting is largely responsible for the decline of salmon in most cases. The question of decayed sawdust, and the effluvia resulting therefrom, is another matter. Aquatic vegetation and the minute forms of life dependant thereon are seriously injured and indeed killed off. That admits of no doubt, but this is not of great moment in regard to salmon and similar fishes, which cease to take food after entering fresh water. How far sawdust affects the smaller species of fishes is an interesting

question, and the late Frank Buckland, in some notes in which he bitterly opposed the pollution of rivers wrote:

'How very important, then, is it to keep pollutions out of salmon rivers; they may not be actually strong enough to poison or kill the fish, yet it is very likely they will deter many from ascending the river.

I think different fish must have different powers of smell; thus gudgeon, roach, &c., assemble at the mouths of drains—the largest I ever caught was in the drain that carries the abominations of the town of Winchester down into the river. Scavenger fish, therefore, I dare say, would not care much about stinking water, but the lordly salmon will not put in an appearance in localities where his 'regal nose is likely to be offended by unsavoury smells.'

'The presence of small species of fish indicates the presence of microscopic food, and if that kind of food be present there is little doubt that the young salmon, if the upper waters be kept pure and unpolluted will survive their journey down to the sea when one or two years old.

On the whole therefore it cannot be maintained as proven that such pollutions as sawdust are seriously detrimental to the ascent and welfare of adult fishes. In the North-west Territories certain coal mines have begun to pour out dust and coal refuse into tributaries of the Bow River and other trout waters. It remains to be seen what kind of injury, if any, will be done to the various species of trout frequenting the rivers flowing from the Rocky Mountain Range.

Certainly it is hardly possible that any rivers in the world are more densely charged with physical impurities than the Fraser, the Skeena and other Pacific rivers. The muddy character of these great rivers always surprises the visitor, who has heard of their pre-eminence as salmon rivers, and the ideal salmon rivers are sparkling crystal waters. These Pacific rivers are vast streams of dilute yellowish brown mud. No contrast could be greater than that of these western salmon rivers and the bright and clear waters of Eastern Canada, or of Scotland and Ireland. Yet the physical impurities of the Pacific rivers have no apparent effect upon the fish, which blindly push their way up the beclouded current until they reach the purer upper waters. The fish can practically see nothing in their ascent, nor can they be seen by man except in some shallow eddy, where their black backs are visible protruding from the mud-laden water in which they are living. The muddy character of these salmon rivers enables great quantities of floating drift-nets to be used, and the schools of fish in their endeavour to ascend push their noses against successive walls of nets and as the meshes become filled with noosed fish, the rest descend and pass under the net only to mesh in the next net further up, and only those which pass net after net in this way reach the waters above fishing limits and continue their ascent up the descending murky current for hundreds of miles. These rivers are fed by tributaries which pour through channels of gravel, gravel famous for the rich intermixture of gold, so that the waters are yellow and turbid for great distances and it is only in the lakes and small upper tributaries that the water is free from diluvium.

The evil effect of this diluvium and of deposits of sawdust falling upon spawning grounds must be admitted, and the killing off of fish-food is another serious aspect of the matter, though this latter question, as already pointed out, is of minor account in regard to salmon rivers. An illustration of the alleged far-reaching effect of sawdust pollution may be found in the Bay of Fundy. In the vast upper stretches of this bay immense schools of 'fall' shad resorted in August to feed. The food, it was generally thought consisted of annelids or shad-worms. In recent years the shad have fallen off so seriously that the fishery is of little account compared with its former extent and value. Sawdust it is claimed floating out of the mouths of New Brunswick and Nova Scotia rivers, has been deposited by the tides upon the feeding grounds, and the shad-worms or food of the shad has been destroyed. This may or not be the case, though I have seen the surface of the sea in the Bay of Fundy covered for many miles with floating sawdust; but it must also be remembered that overfishing in the rivers in spring, when the shad are ascending to spawn, the stoppage of their ascent by dams, etc., must have had some effect, while the ruthless

slaughter of emaciated and weak specimens in their descent after spawning has no doubt had much to do with their destruction.

Chemical pollutions are so varied and complicated, and their evil effects, though admittedly evil, are so diverse that they cannot be dealt with here as briefly as purely physical impurities. Examples could be cited almost without number of the deadly and disastrous effects of deposits of waste chemical substances in rivers. All the rivers in the great manufacturing districts in England and the United States once abounded with excellent fish, but they were used as mere drains for the reception of foul refuse of every description, and these waters were so loaded with offensive and poisonous matter that all fish life has practically disappeared. Scarcely one river can be named in England which is not at some part of its course chemically poisoned, and the inky black noisome rivers of West Yorkshire, of Lancashire and Cheshire are evidence of the direst extreme of chemical pollution, while the southern part of Scotland (except the extreme south-west) and Clyde basin, and the eastern part of Scotland from Dundee to Aberdeen, embrace portions whose rivers are largely contaminated by distillery refuse, tan, fibre, chemical and sewage pollution. The evidences of chemical pollution where it is disastrous should be readily seen. Schools of fish would of necessity be found floating in a dead or dying condition and in course of time the waters would become clearly uninhabitable and denuded of all fish life. The corporation of Newcastle-on-Tyne some years ago poisoned Byker Burn by using a disinfectant of which caustic soda was a principal component. A flood in July carried some of the poisoned water into the Tyne, and for eleven miles every kind of fish was found floating dead or in what was called a 'fuddled' or intoxicated condition. Caustic soda or soda leys is used in many industries, very largely for the purpose of dissolving resinous matters in grass and wood fibres. The dark-coloured fluid (soda and lime) which results is highly poisonous to fish and settles as a deadly putrescent sediment unless swept away by swift currents. If the fish survive, their quality, flavour and colour appear to be transformed. Indeed Mr. Harvie Brown has pointed out that they become utterly unfit for food. The chloride of lime used in bleaching works gives off a pungent and penetrating odour, and has exceedingly disastrous results upon fish life.

Chemical pollutions, as already stated, cannot be dismissed by any inclusive or general statement, though the noxious character of such impurities largely depends upon circumstances. The amount and the possibilities of dispersion and dilution must be taken into account, and it is certain that in some cases (as in bleaching operations) the waste liquids, if commingled, must tend to neutralize mutually their injurious effects. The alkaline and soapy solutions, and the admixture of calcium chloride and of bleaching powder and certain free acids, furnish precisely the elements necessary for neutralization and purification. The chloride of lime will precipitate the soapy solutions, while the free acids will precipitate the alkaline liquids and decompose the bleaching powder solutions. Advantage has been taken by some enlightened firms of this state of things, and without great expense they have adopted an arrangement for purification by mingling in ponds or tanks these antagonistic and neutralizing waste products. The chemical pollutions resulting from various manufactures are too numerous to refer to with any pretention to detail, but a number of more important examples may be mentioned as of special importance. Thus in paper making soda ash or caustic soda is largely used, resulting in a waste fluid of a dark brown hue charged with soda and lime and a certain amount of fibrous and resinous matter. This heavy fluid is harmful both chemically and physically, for it is poisonous, and of a nature so adherent that it lodges in and clings to the gills of fishes. Chloride of lime is also poured out from paper works, where white papers are made, calcium chloride being the bleaching agent used, while colouring matters are added to the waste in factories where blue and tinted papers are made. In recent years many other substances, china clay and mineral matters are mixed with paper pulp, all of which render still more injurious the waste fluids poured into the rivers.

Any one familiar with Yorkshire, Wiltshire and the west of England is well aware that the refuse from the wool-scouring, fulling, and dyeing works is of a most poisonous and polluting nature. The grease and impurities removed from the wool

as removed from the fleece are of a foul character, but still more so the refuse, a disgusting glutinous fluid, full of solid matter and rich in ammonia, which results from the subsequent process in the scouring mills. The streams into which scouring mills empty their waste becoming murky and filthy in the extreme, a stratum of hair slime and effluvium, which must choke even the strongest species of fish. Almost every stage in the various processes of textile manufacture is marked by some additional danger to fish-life. Thus the use of dyes is so extensive in some of the northern and western counties of England, that the rivers flow like streams of variously coloured ink. Many of the dyes, especially the aniline dyes, are less harmful than others, but the waste products of dye works are composed not only of fluids charged with extract of logwood, of indigo etc., but of chemical compounds used in the fixing process, called 'mordants' which may be bi-chromate and bi-tartrate of potash, muriate of tin, copperas, and these together with woolly fibres, and particles of logwood form a mixture of organic and inorganic impurities rendering even the larger streams densely turbid and deadly to fish-life. The bed of such streams becomes saturated with decomposing organic substances, and bubbles of putrescent gases continually rise giving off most offensive odours. Other textile factories such as calico print-works and bleaching houses produce similar waste products including mineral and vegetable dyes, and in a great many cases arsenic, while hydrochloric acid, sulphuric acid and chlorine occur, all of which are inimical to fish-life. Associated with the woollen and cotton-print industries there are others like the flax industry, carried on especially in the north of Ireland, which includes the process of 'retting'. Retting is really the dissolving either by a wet or dry process of the bark and other outer substances from the firm fibrous inner tissue, which is of value for textile purposes. When the flax or hemp is placed, as is largely done, in streams and ponds weighted with stones and allowed to reach a certain stage of fermentation, a dark colour is imparted to the water, and poisonous gases are given off. Professor Reichardt, referring to the retting process said :—

'Taking finally into consideration the fact that 1,000 cubic centimeters of retting water contained sixty-four cubic centimeters gases, whilst repeated experiments with river water showed that the same contained only 30·32 cubic centimeters, the fatal character of the mixture will become still more apparent in its relation to the breathing and life of fish.

'It cannot be doubted, therefore, that retting water will kill fish by its lack of oxygen, if from no other cause. In this all observations made on a large and small scale will agree. The fish immediately gasp for air until they become tired, and finally suffocate. Even leaving this hurtful mixture of gases out of our calculation, it must be granted that putrefying substances must exercise a hurtful influence, both directly by producing changes which are injurious to life, and indirectly by rapidly absorbing oxygen, and thereby depriving the surrounding objects of this gas which is so essential to all life.

'If only small quantities of retting water are mixed with large quantities of running water there may be no immediate evil consequences, whilst if this proportion is reversed the injurious consequences will make themselves felt very soon; in either case, however, poisonous substances are introduced in the water which had better be kept out of it.

'The introduction of retting water into fishing waters should therefore be strictly prohibited, and has actually been prohibited in many places. The retting water may be employed much more suitably in irrigating meadows, where, owing to the loose soil, it loses its putrid character very soon, and aids in forming good food for plants.'

One observer who paid considerable attention to the features observed in 'retting' flax, noted the direct poisonous effects upon the fishes inhabiting the 'retting' waters. He says :—

'As soon as the retting of the flax commences, the water begins to assume a brownish colour and to emit an offensive odour. This colour and odour increase in intensity from day to day, till the water has the colour of coffee, and the odour becomes so repulsive that I have often gone one-half league out of my way so as not to be obliged to pass near such water, especially in the morning and evening. The drier

and warmer the temperature, the more intense will be the odour and the infection of the water.

'Whenever the water has attained a certain degree of putridity all the fish will strive to reach the bank, gasping for air, and in such a state of torpor that they can easily be caught with the hand. If they do not speedily get fresh, pure water, they die, and remain lying on the bank, where they serve as food for birds, or are caught in the grates of mills, from which they are gathered, only to be thrown away.

'At one station I have known years when fish of all kinds were picked off the mill-grates by the hundred-weight, some dead and some alive.'

Curious cases are on record, happily very few, of the destruction of fish by poisoning or asphyxiation, or in some other way arising from natural causes, specially the impregnation of water with toxic vegetable matters. On the great lakes of Canada there is annually a great devastation of fish, principally a species of *Clupea* commonly called shad or alewife, though the former name is wholly incorrect. The fish are practically identical with the gaspereaux which ascend the St. John River and other rivers on the Atlantic coast. It is stated that the fish were introduced artificially many years ago. To quote from the International Commissioners Report, 1896:—

'The alewife is supposed not to be indigenous to Lake Ontario, and the manner of its introduction is not known, but it now seems to be quite firmly established there, and is exceedingly abundant. It has no market value, although it is used to some extent as bait and fertilizer, and is supposed to furnish a large part of the food supply of the lake trout, wall-eyed pike and other species. It is said to spawn along the shores and to some extent in the creeks during the spring. This species has attracted special attention on account of the remarkable mortality which annually affects the schools. Large quantities of the dead fish become stranded upon the shores to the great annoyance of the inhabitants, and the fishermen believe that the pollution of the water and fouling of the bottom by this cause has had much to do with the depletion of the whitefish.'

Some authorities have thought that an excessive amount of vegetable matter, plant-spores, etc., which so charged the water as to impart to it an opaque green colour for a time in summer, is the cause of this mortality. I have found along the great lakes a similar mortality amongst yellow perch, white and black bass, and many small species, evidently due to a poisonous or noxious condition of the water at particular seasons of the year.

In June, 1895, a Quebec journal *L'Electeur*, published a letter addressed to Sir J. M. Lemoine by Mr. Gustave Ouimet, describing a fatal epidemic which had ravaged the fish in the Richelieu River and neighbouring waters. From the widespread character of the mortality amongst the fishes it would seem justifiable to regard the fatality as due to some temporary noxious condition such as might be expected in sluggish and turbid waters, especially during the hot summer months.

The following extract from Mr. Ouimet's letter shows that the disease or affection was not confined to the skin, upon which large round sores, red and white in colour, appeared; but the viscera and interior of the fish appeared to be destroyed, and there appears little evidence to support his theory that the cartridge and gunpowder factory on the banks of the Richelieu River, Vercheres Co., P. Q. was the primary cause of the malady. If these waters, like the more westerly waters of Ontario are temporarily rendered impure, and unfavourable to fish-life during the warmer months of the year by reason of minute vegetable matter, possibly microscopic spores of algae, and lowly plants, the widespread mortality referred to is explained, and the appearance of whitish or reddish sores upon the exterior of the fish and the decay of the internal organs are to be understood as subsequent and secondary results. The following extract from Mr. Ouimet's letter shows the view taken by that gentleman:—

"Il y a quelques années la cartoucherie de Bélœil faisait des expériences malheureuses dans la rivière Richelieu. Il s'en est suivi que des centaines de poissons de toutes espèces petits et gros ont été détruits. Les rives du Richelieu devinrent bientôt couvertes des cadavres de ces malheureuses victimes et la pêche est devenue de plus en plus rare. Depuis ce temps-là les Campbell avaient fait prendre au filet

des poissons de la rivière pour empoissonner le lac de la Montagne. Aujourd'hui le lac regorge de poissons morts et tous les jours on est employé à enterrer les poissons qui viennent mourir et s'échouer sur ses bords.

Je conclus de là, que les poissons tués jadis par la poudre ont été dévorés par des parasites inconnus et que depuis ce temps-là il s'est déclaré une épidémie sur la gente aquatique de nos parages. Les rares poissons vivants que l'on peut prendre à la ligne sont presque tous atteints du mal que l'on reconnaît à une tache, quelque fois deux, une près de l'épaule et l'autre près de la queue.

Dans ces taches se voient à l'œil nu des myriades de petits rongeurs cancéreux qui certainement sont les principaux auteurs du mal. Tout ce que je trouve de poissons morts sur notre grève je le fais enterrer profondément et couvrir de chaux.

Les parasites ne laissent que la peau—l'intérieur du poisson est complètement mangé. Le résultat de tout ceci est, que nous n'avons plus de pêche, que la chair du poisson de notre rivière est dangereuse à la consommation et que de nos rivages s'exale une odeur putride qui soulève le cœur.

Je regrette de n'être pas assez connaisseur pour apporter un remède au mal, et c'est pour nous un grand malheur d'être privés de la pêche qui était si abondante jadis. J'oubliais de vous dire qu'au lac de la Montagne c'est la barbue qui en souffre le plus, dans la rivière toutes les variétés de poissons sont atteintes: carpes, brochets, dorés, achigans, esturgeons. J'ai vu un cadavre d'esturgeon de près de sept pieds de long et pesant à peu près 80 livres, mort, couché sur le dos et atteint sur le ventre de plusieurs des taches dont je vous parlais plus haut, grandes comme des pièces de dix cents, quelques-unes blanches, les autres blanches et rouges; c'est désolant."

Various investigators have described diseases of the integument of fishes due to extremely small parasites belonging to the myxosporidia. These protozoan parasites, as a rule, cause excrescences in the form of pimples and warts, quite unlike the ulcerated and fungus-covered sores due to vegetable affections or to the special morbid condition of organs due to entozoan parasites. There is ground for regarding the unhealthy state and extensive mortality of fishes in the before-mentioned cases as induced by unfavourable conditions and by an environment not merely morbific but toxic and fatal.

About twenty years ago there was a serious mortality extended over a very wide area amongst the sea fishes in the Atlantic ocean, to the north of the Mexican gulf. This mortality was by many authorities attributed to the poisoning of the water by injurious vegetable matters, though others held that some volcanic or subaqueous disturbance had worked the evil. The captain, who first reported the occurrence, said that on his trip from Cedar Key he encountered a wide streak of poisoned water, covered with all varieties of dead fish, of more than a mile in extent, off Indian Pass, between Clear Water and Egmont Light. A very offensive smell arose from it, and a good many bottom fish, such as eels, were floating dead on the surface. A Tampa journal said:—'We opine that this fact upsets the theory of some as to this poisoned water being fresh water from overflow on the mainland, impregnated with poisoned vegetable matter, as there are no streams of any size flowing into the Gulf near where the fish were found.'

Possibly this event belongs to the same class as that of the destruction of tile-fish on the eastern coast of the United States. In my special report upon 'Fluctuation in Fish,' published last year, I referred to that occurrence in the following terms:—

'The disappearance of the valuable tile-fish which for three years (1879-82) was very abundant on the north-east coasts of the United States, was attributed by some American authorities to volcanic causes. Almost in a single night this fine market fish was completely destroyed and the vessel, authorized by the United States government to investigate this remarkable occurrence, found the sea for over 150 miles in a direct line crowded with the floating bodies of these dead fish. Between six and seven thousand square miles were covered by this wave of destruction, and the schools of tile-fish appear to have been entirely cleaned out of that region, though stray groups of them have been reported occasionally, not to be compared with the millions that for the period named abounded in these waters.'

Professor Verrill pointed out that a cataclysm might effect such changes, in what he called the 'warm bolt' of water, as to reduce the temperature and fatally affect the fish. A return of the favourable conditions would bring the tile-fish back, and during the months of August and September last between 300 and 400 of these fish were taken on their old ground during the investigation of the Government steamer *Grampus*, thus indicating that the favourable conditions once more existed there.

It is notorious that chemical works affect not merely the waters adjacent to them, but the atmosphere, and often work great harm upon the health of communities. Factories for the manufacture of bi-carbonate of soda (usually known as alkali) and of ammonia, chlorine and bleaching powders, pour into the rivers sulphuret of calcium in quantity, also chloride of maganese, and many other refuse substances. All these are injurious. The manufacture of soap involves the production of glycerine and saline matters, with oily, resinous and fibrous particles in suspension, and the preparation of hides for tanning, also produces as waste discharges, lime, dissolved gelatine and offensive animal compounds, which have the character of a dense slime of a yellowish colour. Indeed every stage in the process of treating the skins as they come from the slaughter house, results in polluting substances, which are as a rule poured into the nearest rivers. The drainage from the scraping and washing operations and the effluvium from the lime-pits and tan-pits in the shape of lime-water and tan-liquor, are a means of serious and widespread pollution.

It cannot be denied that the most extensive and pernicious pollutions from factories of the various kinds, referred to above, occur in great centres of industry, where the rivers are also largely polluted and poisoned from other sources, especially sewage. Chemical and textile works, tan-yards on an extensive scale, and similar industries are rarely situated in what may be termed the 'upper country,' amongst the mountains and hills, where the most noted and productive trout and salmon reaches are found. It is true that Dundee and Aberdeen are on famous salmon rivers, and reference will be made to these special cases on a subsequent page; but rivers like the Aire, the Calder and other tributaries of the Ouse in Yorkshire, the rivers of the black country, and indeed of the manufacturing districts generally where chemicals, metals, and textile fabrics are worked, are in areas densely populated and destitute of the most important conditions favourable to fish-life in the local rivers and streams. There are, however, many industries which are carried on in remoter and less populous regions. Tin and lead mines are located, usually in mountainous regions near watersheds and the sources and upper portions of trout and salmon rivers. Reference has been made to the 'slime' or washings from these mining operations, the effect of which upon the fish, parents and young, and upon the spawning beds, must be inimical in the extreme. 'It is, I believe, generally understood,' reports one authority, 'that if quantities of slime or solid matter from a mine are run into a river, it gets into the gills of the fish and destroys them:' but such slime contains also highly poisonous matters in solution and in suspension. This 'slime', as it is usually styled, washed from the crushed ore after being repeatedly subjected to running water in order to extract every particle of metal except such as is of the nature of impalpable powder, contains barytes and other poisonous mineral matters. The particles of lead are insoluble and not directly poisonous: but the out-pouring of mine water, where lead-ore is being crushed is found to gradually and surely depopulate all the streams adjacent. The fry as well as the parent fish suffer from the contamination. The construction of 'slime-pits' is not difficult or costly where the refuse cannot be conveyed into the sea directly by conduits: and the abuse is capable of ready remedy. Copper mines are even more deadly in their effects than lead mines, as copper is so readily soluble. In one of the Devonshire mines, the waste water from the mine, and the washing floors, passes through a series of pits filled with old iron. One metal precipitates upon the other and the water finally passes out purified from metal pollution. Indeed it is stated in one report in reference to this mine. 'From these pits the water is conveyed to some catch-pits constructed so as to allow such matter from the matrix as may be deleterious to subside, and strange to say the largest

trout found in the neighbourhood are those in the drain which finally discharges the mine water into the River Tamar.'

It may be added that carbonate of lead also occurs in the 'slime' from the dressing floors of lead-mines. Of course the metal occurs in various combinations, sulphides, carbonates, &c., frequently in very small quantities; but, as has been pointed out, the effects of lead poisoning are cumulative, and hence as pernicious if not more so to fish-life than rapid and direct poisoning, the effects of which are apparent immediately.

The mine-water from ironstone mines and from haematite iron mines is to the eye of the ordinary observer offensive and injurious on account of its thick murky character, and the yellow ochreous appearance it presents. The yellow and red tints imparted to the streams is evidence of the amount of foreign matter in suspension which must seriously affect, if not altogether prevent the respiration of fish. The ochre and reddish colour is due of course to oxide of iron, and an exaggerated example is the coloured pollution produced by the decomposition of iron pyrites, which so long as it is unaffected by air or water and not oxidised remains unaltered, but on exposure to either produces ferrous sulphate, which acidifies the water and absorbs oxygen, thus rendering it less supporting to fish-life. Ferruginous mine-water is charged with ochreous matter usually on account of the presence of iron pyrites. Coal mines, again, injure rivers and streams, as already pointed out not only on account of shale and pyrites which in many ways produce polluting effects, but from the fine coal dust carried away into rivers in suspension and acting mechanically in injuring fish-life. Instances might be quoted without number of which the following, from a report of an officer in Wales to H. M. Inspectors of Fisheries, Board of Trade, London. He said: "For a distance of six or seven miles I found the Mawddach seriously discoloured by the matter which was being poured into it from the Gwynfynydd Gold Mine. According to the quantity of stone which was then being crushed the amount of slime poured into the river would not be less than 25,000 tons a year. No attempt whatever was being made to treat the sludge, notwithstanding the representations made to the company by both the Board of Conservators and this Department. The result cannot fail to be of serious importance to the fisheries of the Mawddach, for the slime, whether or not it is in itself actually poisonous to fish, is of a nature to completely smother the spawning beds with a layer of tenacious paste. The tailings of gold mines either hydraulic on gravel-benches, or stamping and crushing mills for treating quartz and other gold-bearing rock, when poured into rivers are harmful mainly where such waste muddy matter is deposited on or near spawning beds. Many of the evils arising from the mining of metal are repeated in a more acute form in the working of metals and their utilisation in factories. Thus the processes of galvanizing and electro-plating involving the use of various acids, muriatic, sulphuric etc., have resulted in the pollution and poisoning of many streams in England. The manufacture of tin-plate, so intensively carried on in South Wales embraces several processes in which sulphuric acid, copperas or green vitriol are used results in waste products highly injurious to fish when poured as has been done almost universally into rivers. Nail factories and allied industries all use various kinds of 'pickle' consisting largely of various poisonous acids.

In recent years the extraction of paraffin from bituminous shale has introduced another source of pollution in the ammoniacal waste, and offensive organic matters. Tarry impurities have worked widespread harm and universal complaints have arisen regarding the injury done. Even the tar used on certain forms of traps or fyke nets called 'verveux' in the Province of Quebec is said to have resulted in a tenacious scum which has destroyed fish or driven them away. The watery waste, however, which results after the distillation of paraffin oil is regarded as most injurious not only because it is charged with organic ingredients; but its odour and taste are pungent and must be offensive to fishes. Indeed some years ago hundreds of salmon, trout, etc., were found dead along several miles of the River Dee in Cheshire poisoned by the refuse from the paraffin and carbolic acid works, this refuse containing pitch or tar, picric and carbolic acids and other injurious matters.

An industry which has attained some proportions in the Dominion, viz.: the production of wood alcohol has, in other countries, been accompanied by the produc-

tion of poisonous waste, by which rivers have been injured. The processes for obtaining pyroligneous acid, acetic acid and wood naphtha, leaves a tarry residue, and certain alkaline and calcareous products which are poured into adjacent streams when not utilized. Similar oily and tarry refuse has been noticed floating down rivers from gas works, and its tenacious and offensive nature must work harm to fish, though the quantity, as a rule, is small compared with similar waste from extensive chemical and paraffin factories. In several cases of pollution from gas works, a careful investigation did not show that dead fish had been found in the neighbouring waters. Of course, when the production of these waste materials (chiefly ammoniacal, oily and tarry in their nature) is extensive, their utilization is a source of profit, such bye-products yielding valuable substances (staining, saccharine, flavouring, &c.) which are in great demand.

As I have already pointed out in regard to the alleged deadly character of chemical and other pollutions, there is a singular lack of actual demonstration or proof. It is not sufficient to say of a particular stream that fish once abounded there and now they are gone, therefore the factories situated along its banks have killed off the fish with their injurious waste matters. There are numerous cases of depletion of lakes and rivers in Canada, where no such thing as factory pollution has occurred, the decline of the fishery being due either to overfishing, to poaching and destruction of spawning fish, or in some cases apparently to deforestation and cultivation of the land, which has wholly altered the character of the waters.

A clear case of destruction of fish by factory pollution is that of the river Doon, where during the latter part of October (as detailed in the 12th Annual Report of the Scottish Fishery Board), 68 salmon and 62 sea trout, besides a quantity of small fish, were taken out of the river in a dead or dying condition. Dead fish had been noticed by a great many parties, and one party stated that above a certain point very few live fish now occurred. Early in December, outside in the estuary of the river, 135 salmon and 294 sea-trout were picked up apparently poisoned, as there were no indications of fungus, nor were the fish marked or injured in any way. It appeared that the Dalmellington Iron Company, which began in 1893 to manufacture tar, pitch, ammonia, &c., had by an accident allowed a quantity of waste products to escape into the river. A settling pond had been provided, but in October the embankment had given way, and the poisonous products had escaped. The settling pond and certain evaporating contrivances in connection with the works, were arranged to render the wasted matter less poisonous.

Breweries where beer is manufactured in quantities produce waste of a grave noxious character, the acids and other deleterious products, which are produced not only in the brewing of the beverage itself, but in the shape of 'sour beer,' cask-washings, etc., especially in cases where factories are on an immense scale, are inimical, it cannot be doubted, to fish life. Indeed Dr. Tolke in a paper published in 1879 included, as he states 'Among these industries sugar refineries, starch factories, distilleries, breweries and malt-houses whose refuse-water is strongly impregnated with organic matter and causes most of the complaints.

The manufacture of beet-sugar, with which I have been familiar for many years, shall form the subject of a special investigation. This important industry, probably the most important of our agricultural industries, has, thanks to a sensible protective tariff and a rational system of taxation, developed from very small beginnings to its present vast extent.

'This important industry certainly deserves to be protected in the interest of the national finances and agriculture; but it cannot be denied that this growing industry is the very one which contributes the largest share to the pollution of our brooks and rivers, particularly as it consumes an enormous amount of water.

'It will be easily understood, therefore, why the complaints from the beet-sugar manufacturing districts are so numerous and well founded, and every impartial witness will have to concede that the brooks and rivers of those districts produce a very disagreeable impression not only on the eyes, but also on the olfactory organs. Such polluted brooks and rivers are, of course, entirely unfit for fish; but, what is worse, their water cannot be used for drinking and for agricultural purposes.'

The manufacture of beet-sugar, though carried on in Canada, has not yet in any way endangered river and inland fisheries.

In such a country as Scotland where distilleries are frequently situated in the high mountainous country, in order amongst other things, to secure a supply of water suitable for the production of whiskey, the danger of pollution at the very head-waters of important streams and the sources of salmon rivers, is vastly increased. The Fisheries Superintendent for the Spey district, who has many times reported in an interesting way upon the condition of the many salmon resorts in that famous angling area, five or six years ago, gave the following facts in regard to the Fiddich—a branch of the Spey:—

'Last season on this stream there was an increase of about 50 per cent,. of sea-trout beds when compared with the previous season; consequently when we deduct the sea-trout beds, which numbered 210, from the grilse and salmon beds, the real grilse and salmon beds for last season will only count 356. The average number of sea-trout beds on Fiddich during previous years would run to about 100 for the season. The best season's spawning that I have seen on this stream was during the season of 1888-89, when the total number of beds was 1045. During the two following seasons—1889-90 and 1890-91—the total number of spawning beds counted on the Fiddich was even behind that of last season, but, on these occasions, the deficiency was easily explained and understood by the fact that the other tributaries were proportionally behind in numbers. There are now 5 distilleries on the banks of Fiddich in the Dufftown district, all of which discharge their spent wash, spent lees, washings, and 'steep water' into said stream, thus polluting the stream from Dufftown down to Spey, a distance of upwards of four miles. Three of these distilleries—Parkmore, Balvenie, and Convalmore—have commenced work within the last 18 months. It is not unreasonable to assume that the deficiency in the salmon spawning on this stream during the last two seasons is attributable wholly to the pollution of the stream by said distilleries. That the refuse thus allowed to run into the stream from the distilleries is of a deleterious nature to fish was clearly demonstrated by experiments I carried out during the month of June last. I took four samples of water from the Fiddich below the distilleries during the time that a discharge of refuse was running, corked and sealed the bottles; then took a sample from Fiddich above distilleries, and corked and sealed that also. I then took all the samples to Fochaber's Salmon Hatchery, and filled four tumblers with the polluted water and one with the clean sample. From the hatchery boxes I took 25 fine healthy salmon fry, putting 5 into each glass. Result—fry in polluted water died in from one to two and a half hours, while the fry in the clean sample seemed as much at home as if in the hatchery boxes.'

This interesting experiment he followed up later and placed fifteen six-week salmon fry in three vessels, five in each. The first vessel he filled with water taken from the Spey three or four yards from the mouth of the Fiddich stream, which is charged with distillery waste; they were poisoned in an hour and fifteen minutes, while in the second vessel he placed water taken thirty yards below the point where the Fiddich pours in; and the fish died in a little less than two hours; but the third vessel was filled with water taken from the Spey thirty yards above the junction of the stream, and the little salmon continued in a healthy and lively condition. The poisonous nature of distillery waste was thus demonstrated, yet it must be admitted that the number of spawning salmon and spawning beds up the Fiddich showed a remarkable increase in the same year and above the distilleries the eggs and fry could suffer no harm, but all below would no doubt perish.

The manufacture of wood-pulp has attained, in recent years, vast proportions in Canada, and is likely to develop to an extent so enormously increased, in the future, that the effect of the waste matters resulting from such manufacture is of vital concern. In the first place the floating of pulp-wood, which consists of short lengths of very small lumber, is stated to be in many respects more injurious than the great 'sticks' or trunks of large trees which have been hitherto mainly conveyed along Canadian water-courses. The friction of the lengths of pulp-wood, it is said, tears off the epidermis, the corky bark and the fibrous bast tissue, leaving an offensive deposit in the beds of rivers. The trees being small, comparatively young, and of

various species containing more sap and slimy matter than older mature wood of larger growth, there may be increased danger to the fisheries from the development of the pulp industry in this aspect of the matter. The towing and floating of large saw-logs down rivers and over famous fishing grounds in the great lakes has long been a source of complaint amongst Canadian fishermen. These logs, some of huge dimensions, often remained for months in the water, and a large amount of organic matter must have been extracted and permeated the adjacent water. In some cases, especially in the case of hemlock, these pollutions are poisonous in the extreme, and certainly the bark and slimy fibrous debris, scraped off the 'sticks' in their voyage on the water, must be regarded as seriously injurious. The International Commissioners referred to this in the Report in 1896, saying:—

'Among the minor causes to which we may attribute the failure in the whitefish and trout is the deposition of bark from the rafts of saw logs which are constantly being towed across the bay and north channel from some of the larger rivers, especially French River and Spanish River, to the milling ports on the Michigan side of Lake Huron. The grinding of the logs against each other in the booms sets free the fine inner bark which settles on the bottom, forming a thick covering. When this happens to occur on the spawning or feeding grounds of the fish there can be no doubt that a serious injury is caused.

Some of the inshore spawning grounds are said to have suffered from the saw-dust and other mill refuse which has been carried down the streams from the mills; but little injury can have been done in this way, as many of the spawning grounds are offshore or remote from the neighbourhood of the mills, and of late years the regulation prohibiting the letting adrift of this refuse has been well observed. The fishermen seem to have been careful about the disposition of refuse fish and fish offal and have generally landed it on the rocks. As the shores of the bay are not extensively settled other pollutions cannot have occurred.'

These observations confirm the views of the fishermen, who had for many years made their complaint to the Dominion Government, and in 1893 stated their case to the Special Commission, which visited the great lakes in that year, and reported upon this abuse, and on other fishery matters in those waters. One of the witnesses said, speaking of Georgian Bay and the North Channel:—'There are eight different streams and each one used for the floating of logs. The French River, I am told, passed even more logs than the Spanish, and my opinion is that the bottom of the whole lake from Georgian Bay to Mississauga is teeming with bark. It is eighteen miles across to the Manitoulin, and rafts pass in three different directions, so that the bark is spread every way. This bark in the course of time rots and forms into a kind of slime and fish will not stay on that ground. There were five skiffs fishing from here four years ago, since then they have left, as fish got so scarce, and in a very short time I believe there will be no fish at all.

'On September 26 of this year I had thirty-six pieces of net utterly destroyed by this bark. Each piece of net was 180 yards long, and was loaded so heavily with bark as to break the web', and, amongst the additional evidence, it was stated by a prominent firm on the northern shore of the Lake Huron waters, that this abuse was the most serious that the fishermen had to contend with, special stress being laid, however, upon the injury done to the nets. It was stated that bark and the soft wood on the logs which has been found to be very plentiful in the water since the exportation of saw-logs has taken place, is injurious. The stuff rubs off by the motion of the logs while being towed across the bay to the United States, or elsewhere, or even from the rivers when brought down to the saw mills. The rafts are very large, and great damage is done to the meshes of the nets. This is very injurious to the fisheries and clings to the meshes of the nets. It is much more injurious to gill-nets than pound-nets. If these logs are allowed to be towed over our waters, this difficulty will increase, and the prospects for any improvement in the fisheries will not be very encouraging to the fishermen. If the present fishing laws had been in the past carried out as fully as they have been in the past two seasons, and the evils spoken of, and the saw log difficulty were overcome, then fishermen it is claimed would become prosperous again, and would increase

After the raw material, used for pulp manufacture, has reached the mills, it is subjected to the various mechanical, thermic and chemical processes, by which it is claimed that the liquid waste flowing from the mills during those processes is injurious to fish. Widespread alarm, indeed, was caused upon some of the principal rivers of Eastern Canada—rivers, perhaps, the most productive in the world for salmon fishermen, it being alleged that the acids used, and the floating debris, resulted in a polluting waste-product, poisonous and mechanically harmful to fish-life. The actual tests hitherto applied have not borne out these alarming contentions, and it must not be forgotten that the pulp mills spare no efforts to save every particle of waste pulp matter. They use the most recent and scientific apparatus to prevent loss, either of chemical or paper-pulp materials. One of the best biological workers in the Maritime Provinces—a man thoroughly posted in the fish fauna, and the conditions of fish-life in that part of the Dominion, Dr. Philip Cox, made an experiment with a view to deciding the effect of pulp refuse upon living fishes. The experiment does not profess to be final or scientifically conclusive, as the opportunity did not occur to make a full and accurate analysis of the waste materials, which differ at different stages of the pulp-making process, (and the proportions of the components of the waste no doubt vary), but the experiment suffices to show that delicate fish like *Osmerus mordax* are not seriously affected, and salmon, sea-bass, trout, etc., would be even less liable to injurious effects.

DR. COX'S EXPERIMENT.

Tests made April 14, 1895, with waste discharge from the Fibre Company's factory, Chatham, N.B., to ascertain its effects on fish life in the river.

Three vessels of 620 oz. capacity each were used, and were at the beginning of each test filled with water taken directly from the river, the acidulous waste being added.

First Test.

Vessel A, cap. 620 oz. + 2 oz. waste	10.45	a.m.
" B, " 620 oz. + 4 oz. "	10.48	"
" C, " 620 oz. + no waste	10.48	"

Freshly caught and uninjured smelt (*Osmerus mordax*) were put one in each vessel, at the time mentioned. At 12 noon all were active and apparently unaffected.

Second Test.

Vessel A, cap. 620 oz. + 6 oz. waste	12.00	noon
" B, " 620 oz. + 8 oz. "	12.01	"
" C, " 620 oz. + 12 oz. "	12.05	"

At 2 p.m. the fish in C died, but the others were unaffected. I suspected injury to the one that died before it was put in, so in next test I put some quantity of waste in vessel C.

Third Test.

Vessel A, cap. 620 oz. + 12 oz. waste	2.26	p.m.
" B, " 620 oz. + 16 oz. "	2.27	"
" C, " 620 oz. + 24 oz. "	2.28	"

At 3.26 p.m. all active and unaffected. Vessel A was then replenished with fresh water, 48 oz. waste added, and a freshly caught smelt placed therein.

At 4.10 the latter and B and C of the third test were alive and well.

Hence it is seen that a mixture containing 8 or 10 per cent of the waste has no apparently injurious effect.

It is surprising that so little has been done in the way of direct experiment upon living fishes, along the line indicated by Dr. Cox's three tests. I find, however, that some years ago an English chemist confined some small cyprinoids in a vessel of water, polluted by the tarry and acid waste poured into the Dee in Cheshire, by petroleum works and carbolic acid factories. On account of the presence of picric and carbolic acids, the water was yellowish, and it was found that in one gallon of the water there was no less than 7½ oz. of tarry substances. It was found necessary in the experiment to add a quantity (100 per cent) of fresh water, or the fish experimented upon would have died at once. That the water was highly poisonous to fish was proved by its action, even when diluted with an equal volume of tap water. A minnow placed in it made violent efforts to escape, but became still and floated on its side in a few minutes, and in twenty minutes was quite dead. Actual tests and experiments of this kind are urgently needed, in order that prevalent opinions respecting various kinds of pollution may be either confirmed beyond cavil or disproved.

Perhaps the most widespread, and to the general public the most apparent cause of river-pollution is that due to sewage. Cities have from time immemorial regarded rivers as the appropriate channels for conveying away those offensive kinds of waste matters incident to the congregating of large communities. In what precise way sewage affects fish has never been accurately determined: but its injurious effect is a matter of universal opinion. Thus the Canadian fishermen of the Detroit River five or six years ago complained of the amount of sewage poured into that river by the city of Detroit. This sewage and offensive garbage not only polluted the water: but was deposited, when west and south winds prevailed, upon the Ontario shore. 'Since this garbage has been coming ashore' said the fishermen, 'the catch of fish in our nets has been materially diminishing and, if the same continues, the business will be ruined. The presence of the said garbage drives away the fish and renders our fishing privileges useless.' It is not claimed that the fish were actually poisoned and killed: but that they were driven away to other localities. Some authorities who attribute to the sense of smell the action of fishes in forsaking sewage-polluted water, take the above view, and regard sewage as a deterrent more than a direct poisonous agent. This no doubt was the view of Mr. J. A. Harvie-Brown of Dunipace, Scotland, in regard to the Carron when he stated to the Scottish Fishery Board that salmon and migratory trout will not face pollution. The secretary of the Fisheries Improvement Association of Scotland in 1885 said of the Firth of Forth:—

'To recover a stream from a condition of barrenness and resuscitate its fish-bearing powers may be a work of difficulty and of time; but, in the present instance, there is no reason why it sould not be hoped, nay, expected, that the trout and the salmon will (after the improvements proposed are effected) at no distant period begin again to tenant the Water of Leith. The Firth of Forth is frequented by many migratory fish of the salmon kind. Dr. Parnell, in his *Fishes of the Firth of Forth*, mentions not only the salmon and the sea-trout, but some eight varieties of Bull-trout. The sense of smell is believed by scientists to be highly developed in the salmon family, and whilst quick to detect the poisonous effects of pollution, and to be driven away, they are not slow also to detect symptoms of abatement, and to return. It is known that this fish runs gauntlets in the form of filthy waters in a manner truly astonishing. 'Almost every year,' says Dr. Gunther, "salmon and "sea-trout in the grilse state make their appearance at the mouth of the Thames "(where the migratory salmonoids have been extinct for many years) ready to "reascend and restock this river as soon as its poisoned water shall be sufficiently "purified to allow them a passage".'

On the west coast of Scotland a similar state of things has been described on the Clyde and smaller streams such as the Cart, etc. Of the last named river one writer says:—

'In 1819, the Cart was a pure unpolluted stream throughout its whole course, from the upper part of Eaglesham, where it has its source, to its junction, at Blythswood, with the Clyde. It abounded in fish, and was, in its upper parts above Paisley, a fine trouting stream. A century further back the river was famous for fish of the

salmon kind, and so abundant were they that no inconsiderable part of the rent of the Saucer Mill, then belonging to the Stewarts of Blackhall,—an old family now represented by the highly respected Lord-Lieutenant of Renfrewshire, Sir Michael Robert Shaw Stewart, Baronet, of Blackhall and Argowan,—was paid in salmon caught in cruives set below the Linn, then and still forming the dam of the Saucer Mill, and which cruives the miller was taken bound in his lease carefully to maintan and uphold. So recently as the year 1815 we have fished and caught trout in the river near to the Old Bridge of Paisley, while in summer crowds of children were to be seen seeking health and recreation in its clear stream,—wading, bathing, and fishing. Below the town every boy in Paisley given to piscatorial pursuits, had a favourite place of fishing at one or other of the many "yetts" on the towing path along the east side of the river, where he set his lines in the hope of being repaid by a good string of eels and flounders, and occasionally a trout. Now, however, and for many years past, the stream has been a large and greatly polluted common sewer, into which every species of destructive or offensive ingredient, as well as the entire sewage of Paisley and the towns and villages further up, are allowed freely to flow. This most destructive change in the condition of the Cart, when looked at in connection with the present mortality bill of the town, is, beyond doubt, a matter for serious consideration, especially in view of that sanitary regulation and improvement which may possibly be applied in these days when the condition of towns and rivers has forced even the Government to adopt the phrase, *sanitus sanitatis*, as indicative of its policy."

The whole subject of sewage-pollution in its effect on fish-life is a matter requiring thorough investigation. Such investigation might show surprising and unexpected results for at present the views of experts are somewhat contradictory. Thus while on the Thames the pollutions of the lower parts of the river, and the estuary, are said to deter the ascending fish, which linger at the mouth waiting for the coming of a purer current, yet the Tyne, which is even more atrociously polluted, does not deter the salmon and sea-trout, and as Professor Huxley in 1882 said: 'It is difficult to imagine worse pollutions than those which are poured into the 'Tyne at Newcastle, yet the salmon run the gauntlet of the sewage, the chemical 'refuse and other abominations, in sufficient numbers to produce a large annual 'harvest.'

I notice in a report of H. M. Inspector of Fisheries for England and Wales, that sewage-pollution in a case reported upon had, it was claimed, caused the death of fish. The authority mentioned says in his report in 1892:

'Early last year I received particulars of a large "Fordwich trout," said to have weighed 26 lbs., which had been picked up dead in the River Stour, near Canterbury. The Conservators of this District have however, apparently given up as hopeless the task of protecting the river in consequence of the evil effects of the sewage of the city of Canterbury.'

The city of Canterbury has a very small population, and the alleged poisonous effects of sewage, should be even more extensively observed in the Humber, the Tyne and other large rivers which receive the refuse of populous cities like those of the West Riding of Yorkshire, and of the Durham manufacturing and colliery centres. Gottlieb Boccius in his "Fish in Rivers and Streams" published 60 years ago, speaks of the Thames and the Tyne and points out the special features of the latter river as a resort for salmon. He says 'I will make a comparison of the Thames with the Tyne'; no salmon are now caught in the Thames, but though the Tyne has many alkali works on its shores from Newcastle downwards—and alkali is death to every species of fish—yet it abounds in salmon. How is it with these destructive manufactories on its banks, and in despite of the swarms of steam-boats and tugs ever passing up and down the river, it is still a good fishery? Why, simply because Salmon and all other fish, migrating from water to water, never stop on their way, but push forward, and that at a fast rate, till their intended journey, for which Nature prepared them, is completed for, as I have said, Salmon being very swift, soon pass through the water which is offensive, and then run for the pure springs fit for spawning.'

In the report for 1887 of Mr. Fryer, one of Her Majesty's Inspectors of Fisheries in England, to whose able and very comprehensive and detailed reports I am so largely indebted in compiling these notes on pollutions as affecting fishery resources, it is stated that while the Tyne is the most productive of all the salmon rivers of England and Wales and one of the most extensively polluted by sewage, mining refuse and manufacturing waste, liquid and solid, yet its salmon harvest remains wonderfully good. Its productiveness was, however, stated to be on the decline; but whether due to pollutions or to overfishing could not be decided, though it was pointed out that the large body of sea-water pouring up the tideway no doubt did much to counteract the evil results that might otherwise accrue. Certainly the catches of salmon by net and by fly on the Tyne have during the last quarter of a century been wonderfully maintained, and the river has apparently been as well supplied with fish as the most optimistic could expect. Thus in 1886 and in 1887 the takes were 25,696 and 18,835 respectively. Five years later 1891 and 1892 they were 29,298 and 31,080 respectively, and at the end of another five years 1896 and 1897 they were 15,755 and 11,081 respectively. The last published figures 1898 are reported as showing an average catch, the quantity being 11,422. The Tay in spite of the fact that Dundee, Perth and other centres of population occur along its course is by no means denuded of its salmon, though the catches during recent years have been below the average. How far these decreased takes in the river are to be accounted for by the destructive netting and trapping along the estuaries and seashore it is not easy to decide. The Tay like all salmon rivers is subject to remarkable fluctuations and it is interesting to note, as indicating the continued productiveness of the Tay, that its annual rental (that is the amount received by the riparian proprietors for the netting and angling privileges), amounted in 1898 to over $100,000; in the previous year to over $85,000; and in 1894 to $95,000.

What is the conclusion which the intelligent observer must reach, who glances over the series of facts and inferences briefly set forth in the foregoing pages. In the first place it is evident that circumstances modify the effects of all forms of pollution, so that waste matters which would be deadly in one river, will pass away and prove of little harm in another, where the conditions are different. In the second place it shows how varied are the effects of various waste products under the same conditions upon different species of fish. Salmon will survive unharmed where shad and gaspereaux would be killed off.

Further these notes indicate how little is actually known of the effects upon fish-life of these various pollutions from accurate and thoroughly scientific experiment. Common opinion and popular ideas more largely prevail than reliable and demonstrated knowledge. Nor must it be forgotten that, however pure and free from pollution rivers may be made by rigorous enforcement of laws against such offences, it is vain to expect a restoration of the fishery resources, and the repeopling of depopulated waters, if the parent-fish are shut off and obstructed by mill-dams, canal locks, timber refuse, log-jams, booms and fallen trees, or any obstacles by which they are prevented from reaching the spawning beds. If the spawning grounds be kept free from pollution and the deposition and fertilization of the eggs be accomplished; and if moreover free and unobstructed access to these grounds be provided for the fish, and, above all, if over-fishing, excessive netting and destruction of the ascending fish be prevented, there need be little fear that our supplies of salmon and valuable migratory species will wholly fail. The assistance of artificial fish-culture will be an effective adjunct.

There may be cases where the erection of mill-dams and pollution by poisonous waste products is of more moment than the destruction of the fisheries in a particular river. The utilitarian motive may be overwhelming, and valuable industries on a large scale may, in some cases, outweigh fishery interests and considerations. Of the serious results to a community from a too rigourous enforcement of fishery laws, a striking example has been recently afforded in King's County, Ireland. In a local journal it was stated that 'the fine mills of Springfield and Belmont, which are owned by Mr. Archibald Coulahan, are to be closed shortly. The owner is taking this course in consequence of the Fishery Conservators compelling him to

do work in the way of putting up gratings, which he considers both unnecessary and impracticable. There is great regret felt in the neighbourhood that those mills—which cost some £50,000—should be closed, as many hands will be put out of employment. It seems a great pity that the rival interests of fishery owners *vs* mill owners should be allowed to clash in this way.

The salmon fisheries of Ireland are no doubt of much importance, but in a county with so very few manufacturing industries it is a fatal mistake to place any obstacles in their way.'

The public interest must of course be paramount, but the highest authorities are agreed that such cases if they exist at all must be rare, and it is of prime importance to remember that there are few factory pollutions which cannot be readily and inexpensively rendered innocuous. Indeed I cannot do better than quote, in a concluding sentence, from the Tenth Annual Report of the Scotch Fishery Board, which puts the matter succinctly, and urges considerations which must have weight with every fair and intelligent mind:—

'Legislation for the prevention and cure of pollution and poisoning in all running waters is most important and urgent. The evil is yearly increasing, and it is time that a remedy was applied. And that such a remedy might be found without injury to manufacturers there seems to but little doubt; as, more than fifteen years ago, the River Pollution Commissioners wrote as follows in their fifth and last report:—"We "have thus already submitted to your Majesty a description of the evils arising from "the discharge into river channels of town sewage, and of the various filthy drain-"age waters from cotton, woollen, silk, flax and jute works, from print and dye-"works, from tanneries, paper mills, and bleach works, from alkali, chemical, and "soap works, from distilleries, starch and sugar works, and from paraffin oil works. "The remedies for the nuisances which these refuse liquids create have been care-"fully examined, and, after prolonged inquiry and research, we have been able to "report that in every case efficient remedies exist and are available; so that the "present use of rivers and running waters for the purpose of carrying off the sewage "of towns and populous places, and the refuse arising from industrial processes and "manufactures, can be prevented without risk to the public health or serious injury "to such processes or manufactures."

'It seems therefore quite evident that the secondary uses of water which the manufacturers enjoy have been too long allowed to usurp the place of the primary uses to which the public are entitled, and that it is high time that stringent measures were taken to check the progress of pollution, which has already converted so many of our streams, once pure and pellucid, into mere fetid sewers. In one way, at least, the public health and the preservation of salmon are immediately connected. The water which will destroy or repel salmon is not fit for human use; and the water fit for human use is attractive and wholesome for salmon.'

The fact cannot be ignored that almost daily such improvements are being made in the methods of treating raw products and of utilizing waste materials that some of the industries referred to in the preceding pages have in recent years undergone total change. To a large extent pollutious which have hitherto been a main source of danger are ceasing. Thus at Ottawa itself where probably over one hundred million feet of waste,* in the shape of sawdust, have for many years been poured into the fine river which flows by the Canadian Capital, a revolution may very soon be effected, and the sawdust hitherto so lightly valued turned to practical use. The utilization of waste products is a hopeful sign, and will do much to rectify the evils arising from industrial pollutions, which have so long afflicted fish and fisheries.

* It is stated that there is one foot of waste to every foot of timber cut in the mills.

NEGLECTED STRUCTURAL FEATURES IN YOUNG FRY.

By Professor E. E. Prince, Dominion Commissioner of Fisheries, Ottawa.

It is a curious circumstance, the explanation of which is not easy to find, that pisciculturists have been almost without exception what are called 'practical' men. By that term is meant men who did not claim to have much professional knowledge or technical training. Many of them, especially the pioneers in artificial fish breeding, did not hide their contempt for theoretical knowledge, and viewed with little favour scientific training, or the opinions and explanations of scientific specialists. Just as the Scottish fishermen frequently claimed that during the sittings of the British Fisheries Commission in 1885, they taught Professor Huxley a good deal about fishes, though that famous biologist was amongst the greatest masters in the science of fish that the world has seen, so the early fish-culturists often congratulated themselves that they adopted courses not fully in accordance with scientific opinion, and proclaimed the sufficiency of 'Practice' without 'Science.' One of the most striking cases of this feeling was that excited when the retention of salmon in tidal ponds was tried. Biologists, on scientific grounds, demurred to the keeping of parent salmon in salt-or brackish water, long after they should have ascended into the pure fresh water of the upper reaches or spawning grounds. Physiology would discourage the retention of parent salmon in the midst of conditions not in accord with the conditions which obtain in nature. The experience of the practical man, however, prevailed, and so far as can be judged, tidal ponds are a success, and the eggs and fry do not apparently differ in health, vitality and successful incubation from those secured from parents which have reached the head-waters far from the sea. Of course the question is one of a somewhat complicated and profound nature when thoroughly analyzed, and the biologist must reserve his opinion as to the ultimate effect, through heredity, of the changed parental conditions upon succeeding generations of fish. So far no specially abnormal or undesirable effects have been noticed, and the parent salmon certainly maintain a more robust vitality, and are freer from fungus and disease than fish taken on the spawning beds at the head waters of salmon rivers.

Experience, of course, is the best of all teachers, but practical experience combined with exact scientific knowledge, is better still; for the pupil is no longer simply taught, he becomes a master and can control and command. Experience gives us the 'how,' but accurate knowledge provides us with the 'why,' and the fish-culturist who handles ripe eggs, who vivifies them by the admixture of the fertilizing milt, who is able to recognize living and dying or dead eggs, and who knows when the eyed stage is reached, and can accurately tell when the period of hatching is approaching and the young fish are about to emerge, such a man will feel increased confidence in the progressive steps of his work, and will avoid some mistakes and surmount many difficulties if he has technical and theoretical knowledge added to his valuable and indispensable practical experience.

The complaint has been frequently made that no results appear to have followed from the planting of artificially hatched fry, and doubt has been thrown upon the success of all fish-culture work. Examples might be readily given, but the well-known case of the Delaware River, Pennsylvania, may be referred to. In 1871 a number of gentlemen in Philadelphia and Easton procured 10,000 salmon eggs from the Canadian hatchery at Newcastle, Ont. Under the superintendence of Messrs. H. A. King and Christie about 2,500, all that survived from the incubation of the 10,000 ova, were planted. In 1872 Mr. Thaddeus Norris hatched 11,000 fry out of 13,000 eggs, and the following year Mr. Norris and Dr. Slack planted a considerable number of young salmon. No adequate results were ever seen, and the three attempts to stock the Delaware were looked upon as failures, and the State Fish Commissioners concluded that 'the waters of Pennsylvania are evidently not suited to this fish, however desirable it would be to have it planted and thriving in them.'

There is reason to believe that the non-success arose less from the unsuitability of the waters than from some defects in the method of handling the fry. Indeed the weak condition of the first batch of fry was noted at the time, and it was attributed to the hot weather. It is undeniable, however, that in spite of sultry conditions and untoward circumstances, fry can be successfully planted if knowledge and experience are available, and proper provision made to guard against all harmful influences.

The present brief notes on some neglected features in the newly hatched fry of fishes do not refer to any new scientific or biological points unfamiliar to the trained specialist. Nor are they intended to essentially modify the handling of eggs during incubation or the treatment of young fish after hatching. They refer to some points, familiar enough to the embryologist, and no doubt known to pisciculturists in general, but apt to be overlooked or neglected when the time comes each season for taking care of the newly hatched fry. These points have reference to peculiarities in the structure of the young fishes at the close of incubation, and upon their entrance into free life after leaving the egg. They are of importance, and by ignoring them the health and vitality of the fry may be impaired, and even loss of fry entailed.

First of all it is to be noted that the fry of fishes usually included in fish-culture operations possess enormous eyes. Lake whitefish, great lake trout, brook trout, pike-perch or wall-eyed pike, and other species, exhibit eyes of extraordinary dimensions, occupying in some cases fully one-third of the lateral surface of the head. No doubt the real significance of these large organs of sight, so disproportionate to the size of the microscopic larva must be explained on principals of development and evolution. They are like two black or densely coloured balls, which are readily seen long before hatching, and while the young fish is being formed inside the egg-capsule. They are so prominent and visible that the term "eyed-egg" stage is in common use amongst fish-culturists. To the practical man the possession of a pair of large sensitive organs of sight is a warning to him that the possessors are easily affected by rays of light. It teaches him that as far as possible reflected light should reach the tanks or vessels containing them. Hence direct rays and an excessive amount of light of any kind is not only unsuitable, but is highly injurious.

Glaring light, such as that produced by modern types of gas-burners which increase the luminosity of the inflammable medium, and incandescent electric-light devices, are to be strictly avoided. The sensitive eyes, with their large receptive pupils, cannot bear light so steady and piercing. Pisciculturists, as a rule, have arranged the windows etc., so as to shut out all excess even of day-light, and have done so mainly, because too much light was known to be favourable to vegetable parasites and algoid growths. Fungus has been generally held to be stimulated by abundant light. But the reason which above all should guide the fish-culturist in regard to light in hatcheries is the anatomical and physiological reason, viz: the perilous results to the fry, which excessive light inevitably brings, on account of the great size and unusually sensitive character of young fishes' eyes. As every one knows, the eyes are protruding and prominent and not shaded by eyebrows, eyelashes, or protected by movable eyelids, hence a glaring light which is painful to the visual organs of higher animals, is not merely disagreeable, but productive of morbid and fatal effects, if allowed to shine upon embryo fishes and fish-larvae.

During incubation a suitable amount of light is very necessary, or the development of the eggs will be delayed; but it must be reflected light of the sun, such as reaches them on the gravelly 'redds' or spawning grounds. Eggs of fishes being, in so many species, deposited in shallow parts of the upper reaches of rivers, where the water usually is swiftly running, and broken up into ripples, each ripple and crystalline wave acts as a refracting prism, breaking the glancing bright rays of the sun into scattered reflections of light. Thus the solar rays even at midday are bent by the uneven surface of the rushing water, and directed into the hollows, the interstices, and shadowy ridges of the gravel and boulders beneath the surface. Many pisciculturists have learned to their bitter cost, that, too much light especially, when accompanied by a high temperature is most unfavourable, hastening unduly the progressive stages of development during the incubation of the eggs, and resulting in weak and sickly fry which are unable to survive through the first few

weeks of larval life. The cylindrical glass jars in which the eggs of many species are hatched, though cleanly and convenient, are wholly unadapted for holding the fry, and the more rapidly the young fish are enabled to pass from the dazzling glare of the crystal vases to the more shady and gloomy surroundings of the large receiving tanks the better for the fish. Assistants in hatching establishments rarely realize the harm that may be done by allowing fry to remain a few hours, or it may be a whole day, exposed to glaring light, and they should be strictly instructed on no account to keep fry longer than can be avoided in the blinding light which beats upon them after they emerge from the eggs in hatching jars. There is not this danger in the case of fry which are hatched out upon trays: but towards the close of the period of egg-incubation, hatchery officers should keep a sharp eye upon the hatching jars in which whitefish, or shad, or pike-perch (doré) are developing to see that the current is adjusted sufficiently to carry the fry off without any delay. Experienced men are frequently puzzled by the apparent weakness and lack of vitality in whole batches of fry, while others are robust and strong. The explanation is not far to seek, for in most cases it will be found that the weakly fish were delayed too long in the glaring environment of the hatching jars.

Again, it must be remembered that larval fishes possess extremely delicate hearing organs. The ears, one on each side of the head, a little in front of the breast fins, are of an oval shape, like an egg-shaped sac or chamber, filled with clear fluid or endolymph, and containing one or two, sometimes three, small limy pellets, the ear stones or otoliths. Several sensitive cushions of nervous matter, studded with hairs or delicate bristles, occur inside the chamber of each ear. These cushions are connected with the auditory nerve, or nerve of hearing. The ear is completely closed up, and receives vibrations or sound waves through the delicate walls and skin covering the head. Shaking the fish rudely, rough handling of any kind, and loud hammering, or other violent noises, cause the ear fluids inside the ear-sacs to vibrate too vigorously. This produces concussion of the otoliths or ear stones, which may even be knocked out of their places, damaging the delicate auditory cushions of nervous matter, and producing serious disorganization.

Damage done to the ears may result in sickness and rapid death. The intelligent fish-culturist will take every means to avoid all perils and risks, and will bear in mind that fishes when newly hatched have hearing organs of special delicacy and sensitiveness.

A further point, which is often overlooked in hatcheries, is the character of the skin in young fishes. It is not provided with scales, as in adult fishes generally, or dense and leathery as in catfish, the leather carp and many mature forms, but in all young embryo fishes it is naked and very thin, and often as transparent as glass. Indeed, as the Michigan State Fish Commissioners remark in their 12th Biennial Report, 'The fry of whitefish are so transparent for several weeks after hatching that, when confined in glass aquaria in a well lighted room, the presence or absence of food in the stomach may be determined almost at a glance. The presence of their natural food is especially noticeable, as it casts a reddish tinged line throughout the food canal.' Many larval fishes, moreover, are provided with external sensory organs arranged in a series along each side of the body. In some the tips of the jaws and the front end of the snout have similar organs of feeling or touch. These organs are usually like small mounds or bunches of nervous cells, surmounted by a group of projecting hairs. I have counted as many as seven to ten pairs of such organs in the body of a young fish. Some fish have more, some less, but in all cases they are so sensitive that they cannot fail to be seriously injured by rough treatment or violent concussion. Hence fish larvae must always be gently manipulated. In emptying large quantities from one vessel to another, they should not be violently poured out, with accompanying splashing and concussion, nor should they be suddenly transferred from a high to a low temperature. The skin and delicate sense organs of fishes are as sensitive as the eyes or the tip of the tongue in ourselves, and all harsh or hurtful influences and trying conditions render the fish less likely to survive, or may even prove immediately fatal.

It is a good provision to test the temperature of the water in which the fry are contained and the temperature of the water into which they are to be emptied. In

the case of lakes and rivers, warm shallows or sheltered eddies can easily be found, if the open water appears to be too cold.

Many other points, known to the scientific specialist, might be mentioned, but in this paper one further point only will be referred to, viz., the presence of a delicate erect fin along the back, and along the under-side of the body as far as the posterior side of the yolk-sac. This transparent fin-membrane is so thin, colourless and clear, in the whitefish, the shad and the alewife, though more dense in the salmon and trout, as to be almost invisible, unless carefully looked for. It is really a broad sheet of extremely thin skin standing up in the middle of the back of the fish, like a delicate crest. It is known to embryologists as the unpaired continuous fin-membrane and is so easily injured that newly-hatched fishes should never be handled. Sharp implements and hard substances rupture it, and most cases of curled, distorted young fishes are found, on examination, to be due to injury of the embryonic fin-membrane. The tail, especially, is liable to curl up on this account, and the fish has a crumpled and whitish appearance. The practical pisciculturist is often puzzled when he sees abnormalities and morbid appearances in his fish and cannot understand why eggs which were so healthy, and hatched so successfully should at times result in disappointing, sickly, and dying embryos. It is often difficult for him to discover the why and the wherefore; but some knowledge of the minute structure of newly-hatched fishes, and some acquaintance with their physiology, will often throw light upon his difficulties and prove in numerous ways most helpful. Indeed some knowledge of the scientific principles of development and embryonic anatomy is necessary for the successful handling and proper treatment of young fishes incubated and hatched under artificial conditions.

THE OBJECT OF A CLOSE TIME FOR FISH.

BY PROFESSOR EDWARD E. PRINCE, COMMISSIONER OF FISHERIES, OTTAWA.

The question is often asked "what is the object of a close time for fish?" and the answer is by no means so simple or easy as is generally imagined. The object of a close time varies greatly according to circumstances, and the criticism often urged against legal enactments which specify certain seasons or periods as times during which the taking of particular species of fish is prohibited, are frequently misdirected and mistaken. Thus it is often said of some fishery regulation, embodying a close time, that it does not cover the whole period of spawning and that many fish are found, before and after the limits of the period, in a ripe or spawning condition. The critics in such case base their remarks upon the supposition that a close time of necessity aims to cover the period during which the fish spawn—the fish that is to say contemplated by the regulation. But such is not at all the sole object of a close time or close season. Again, it is said that in some cases the period of prohibition antedates or precedes the spawning time, while in other cases it protects the fish after spawning. In other words the close time is too early, or it is too late.

Fishery authorities in framing regulations defining close times for various kinds of fishes often have had very different aims in view. Indeed, at least a dozen wholly diverse objects have been aimed at in existing laws upon this subject in the Dominion, and a comparison of the laws in other countries defining close times would increase the number to over a score. It is rarely, however, that a close season is enforced so unjustifiable and futile as that which was passed by a local legislature in the United States, according to whose enactment no whitefish could be captured in Lake Erie during the month of June by any fisherman in that State. The main reason for this law, which it was proposed to rigorously enforce, being that no fisherman could ever catch any lake whitefish in paying quantities at that time of the year. Further reasons were that the weather being hot the few fish, that might be taken, would not keep in good condition for the market, and the fishermen lost money because their nets became foul and rotted away during the height of summer. In the State referred to there was no protective close time in November when the whitefish could be captured crowded together on the spawning grounds in immense schools. The sole object of a close season for whitefish in that case was to meet the desire of the fishing firms and the fishermen for a prohibition to be enforced during a part of the year when they would not feel it. Some years ago a large number of lobster fishermen in the Maritime Provinces urged that a close season for lobsters be enforced all along the coast at the end of June, because they had to go to cod, haddock, and mackerel fishing, and could not go on any longer with lobster trapping. They desired that no other fishermen should be permitted to fish for lobsters, when another more important fishery demanded their own attention. In all such views, on the matter of a prohibited period for fishing operations, the protection of the fish is left entirely out of account.

There can be no doubt that the main object of close seasons in the majority of cases, has been the preservation from destruction of the breeding fish at the most momentous period, viz: when just about to deposit or incubate their eggs. If this object can be accomplished it is the most effective measure possible for the perpetuation of the fish supply. The destruction of the breeding fish, at the very time they are engaged in spawning, is the surest step to the extermination of the future supply. Yet this destruction has in past times been almost universal and those engaged in fishing for a living, those to whom a continued supply is of chief importance, are often the most impatient of restrictive laws, and frequently

complain that the law stops them just when the fish are running or schooling in easily accessible areas, and when therefore the greatest hauls can be made.

The fishery officer is not unfrequently taunted with this remark 'if you kill a female fish six months before spawning, you just destroy as many eggs as if you killed her six days or six hours before depositing her eggs, nay in the act of depositing her eggs.' It does not demand much intelligence to see that this is wholly untrue. An artist painting a picture experiences a far greater loss if his painted canvas be destroyed after he has expended many months labour upon it and when just about finished, than he would if his canvas were destroyed after he had merely put a few touches upon it, on the first day of his work. Out of a thousand fish in June, it may be that not more than 200 survive until November to spawn, hence a spawning fish in November, in such a case, is of the value of five fish in June, from the fishery protection point of view. The value and importance of a breeding fish is vastly increased with the approach of the breeding season. Thus there is necessity for protecting the parent fish of valuable species, with the utmost strictness, at spawning time. As there is always some slight variation in the spawning operation in different individuals, a close season rarely attempts to cover all possible spawning specimens. The lake whitefish which is one of the most regular and rapid spawning fish varies a little in different years, but on the whole the month of November covers the main period in most provinces of the Dominion. This year in the Detroit River the season was at least two weeks later than usual, and in the North-west Territories some whitefish have been found containing ripe spawn in October, and again others in December. The so-called lake-herring or lesser whitefish, usually regarded as spawning in November, has been found carrying ripe eggs in June, a specimen four or five years ago being sent to me from Lake Erie by Mr. Edward Harris, of Port Dover. It is usually most desirable to protect every spawning fish possible, of valuable kinds; but in other cases as in the great lake trout or salmon-trout of the lakes there is much to be said in favour of the present season, viz: November, in Canada. Their main spawning period is late in October, and as the law stands great numbers of ripe spawning fish are taken annually although this year they were later than usual. The great lake trout is a strong, predacious and in some respects, undesirable fish, making war upon whitefish and all other kinds. It does not require the same amount of legal protection as a defenceless weak species, like the toothless whitefish, hence it suffices for the 'fresh-water shark', as the great lake trout has been called, to be partially protected only, so that they may not exterminate equally valuable kinds and over-run the waters. The present close season for the great lake trout is perhaps too short, but it has sufficed in Lake Huron and Georgian Bay at any rate to ensure the maintenance of a fair supply of these fish. It is plain that predacious species call for less protection than more harmless and defenceless species. A similar observation may be applied to the speckled-trout or brook-trout. It spawns over a very long period from November until April, but a close time of six months or more could only be justified on the ground that the species requires the preservation of every spawning specimen, a contention for which convincing evidence would not be easy to adduce.

The conclusion was reached by the Tweed Salmon Commission in 1896 that the supply of salmon can be kept up, if a sufficient proportion of each run of fish is enabled to reach the rivers and ascend to the spawning grounds.

This is the great argument in favour of a weekly close season on salmon rivers; but there is no doubt on some of the great rivers of Canada, as on the Fraser River or Skeena River, that the fish which have passed the lower fishing grounds during Sunday are overtaken on Monday morning by fishermen who hurry to the highest limit up the river allowed by law, and capture the fish after the first few miles of their ascent. This may be so on the Restigouche and other eastern rivers where the nets, some miles up the river, take the fish on Monday which have passed the lower nets in the estuary during the Sunday close time. An annual close time is necessary not only to supplement the partially ineffective weekly close time; but to render illegal the capture and handling of spawning fish by poachers.

In all civilized countries, possessing salmon rivers, a rigidly defined close time covering as far as possible the spawning season, has been enforced and with good

effect. Fish taken illegally during the 30, 40 or 60 hours weekly close time may be legally possessed and sold, on Monday or Tuesday, if the illegal capture be not detected. But it is difficult to keep illegal salmon during a long annual close time, without risk of detection, and if discovered, their condition proves them to be unseasonable and illegal fish. Moreover an annual close season may be enacted (like the ten days close time in September in British Columbia) for several subsidiary reasons as for instance to prevent the capture of very late incoming salmon, like the last stragglers (discoloured, soft and disgusting in appearance) of the Blue-back or, Sockeye run, and to cover simultaneously one of the earliest runs of Cohoe Salmon both of them very desirable objects, the one on economic and health considerations, the other on protective grounds, thus the canning of salmon in bad condition, and the perpetuation of an early run of a valuable species are accomplished by this ten days interregnum. Fishery regulations *per se* have no direct connection with health or sanitary regulations, yet the purposes of the latter regulations are often indirectly aided and accomplished by the former. Fish in an unseasonable, emaciated and degenerate condition cannot be good food. The Pacific Salmon which have mounted many hundreds of miles, are ill-conditioned, semi-putrid and wholly unfit to be eaten, yet they would be largely consumed, and many factories would not hesitate to can them, did not the law (by close time regulations) prevent it. In remote districts, Indians and white men too, are said to use them for food and outbreaks of disease may be often traced to this cause.

Oyster regulations have had a similar object largely in view, and have prohibited the taking and sale of 'sick' or spatting oysters as much on grounds of health, rightly or wrongly, as for protection purposes.

Close seasons as a rule cover periods when fish may not only be taken more numerously (as they are then schooling) but more easily (as the females are more heavy with spawn;) but they are also intended to protect the weakly emaciated spent fish after spawning, as well as the vigorous 'full' fish before spawning. It is well known that shad on descending from their breeding grounds up river, are little more than skin and bone, yet worthless and emaciated though they are, the fishermen strain every nerve to capture them. A Shad close time should cover the descending fish as well as protect the ascending schools. The same reason may be urged for a long close season for salmon. It prevents the capture of black slink salmon and unsightly kelts. It no doubt enables the young fish, the smolts, to descend to the sea undisturbed. There is every reason to prevent a river or lake from being disturbed all through the year by fishing operations, and the fish harassed and driven about by long lines of nets.

The Canadian regulations for salmon, etc., have worked untold benefit in preventing the continuous disturbance of the fishing grounds from January to December. Had it been permitted, the fish would no doubt forsake such waters, never to return. Special close times, covering several years in some cases, have been devised to restore depleted fisheries. Thus in 1892 a close time for three years for striped sea bass was enforced in New Brunswick. The beneficial result was most marked, and the fish which had been almost exterminated increased—more rapidly than either the authorities or the fishermen could have reasonably anticipated. All fisheries are not so readily restored, and a long period of prohibition in the St. John River, in New Brunswick, appears to have been ineffectual to restore the depleted and destroyed sturgeon fishery there. The same difficulty in restoration, by a lengthy close time, has been observed in lobster fisheries, when these have been once depleted.

It has been possible, in the case of some fisheries, to so arrange the annual close time, that the fish about to spawn are protected from capture before the actual spawning period. The smelt, for instance, do not spawn as a rule for some weeks after the present close time begins, but as the netting season draws to its end a vast number of smelts are found to be swollen with eggs that are rapidly approaching the ripe stage. It is no doubt due to this antedated close time that the smelt still abound in vast schools at the mouth of the Miramichi, the Richibucto, the Restigouche and other rivers, although as many as 4,000 or 5,000 tons have been captured during the short netting season of a few weeks. A close season to achieve fully its object should, if possible, protect the first as well as the last spawners. It

should do this in order to keep up the early runs, which in most marketable fish are by far the most valuable. It should also prevent the last spawners from being captured, as the late fish are always in a poor, flabby and unseasonable condition for food. The capture of early runs has in the case of salmon rivers had the effect of wholly destroying them and of rendering such rivers late. Late rivers imply a large proportion of degenerate, unsightly and undesirable fish. Prohibitions again have been enacted to prevent the disturbance of one kind of fish by fishing operations carried on for other kinds of fish. Thus nets for whitefish, pickerel or dore, and for coarse fish such as catfish, pike and suckers were prohibited in the Bay of Quinte for many years, not to protect the fish just mentioned, but on other accounts. Thus in summer such nets would take spawning bass, or, at any rate, would disturb them while spawning, and later would interfere with the bass anglers who desired these fine black bass grounds to be free from nets at the time. The fishermen themselves were not strongly averse to this summer net prohibition for three reasons—(a) they were employed by the anglers as boatmen and in other ways; (b) their nets readily rotted and became useless if used in hot weather; (c) catfish and other coarse kinds are soft and in poor condition in summer and fall, whereas in the cold winter months they are most valuable and in prime condition for market.

Very various, indeed, are the grounds for enacting close seasons and the reasons for enforcing them, but the ultimate object is the promotion and improvement of the fish supply, and conferring thereby substantial benefit on the fishermen and the public.

It is from the fishermen and from the public, therefore, that the authorities ought to look for every aid in the laudable task of fish protection. That such aid is not always to be relied upon is a matter of common knowledge. Indeed, it is too often the case that the parties likely to derive most benefit permanently from a brief protective prohibition do not realise that such benefit must inevitably accrue to them.

The published views of a well known Ohio fisherman may be given as an example. He said:—'Regarding this matter of a close season I have certainly some convictions. The difficulty along our part of the line of Lake Erie, which we have to encounter, is that the time that you can take these fishes best for the market is in the month of November, and in no other month to speak of can you take any whitefish in the head of Lake Erie. It is true that the head of Lake Erie is the natural spawning ground probably for the whitefish, but if you do not take them in the fall with pound-nets and other appliances in the head of Lake Erie, they must then take them with gill-nets. Now there is no use of making a close season to shut out this fishing article of food. You take the fishing of Ohio, and you take the month of November out of the fishing month, and you might just as well hang up your nets entirely on the American side, that is, on the headwaters. The month of November is the only time that it is possible to catch the fish, that is fish for commerce.'

A prominent member of a fishing firm in Michigan said: 'I think a close season to commence the first of September and end the first of January, would be what we ought to have. I think the State ought to take the money that is expended in hatching fish, and pay the fishermen to stop fishing during the close season; that is, pay the fishermen for their time while they are lying still in the fall, during the fall fishing season.'

Such an expression of opinion is proof of the unwillingness of the fishing community to realise the purpose and meaning of close seasons for fish. Public opinion does not appear to have reached the necessary state of enlightenment. The California Fishery Commissioners when they reported regarding salmon protection on the depleted Sacremento River in 1882, said:—

'The Commission has much satisfaction in being able to report that there now appears to exist a more harmonious feeling upon the necesity of preserving the fish in our rivers. During the year last past, from all the information we have, there has been exhibited, on the part of the conductors of the canning business, a fair and earnest desire to enforce the close season, and a commendable realization of the importance of preserving the fish from wasteful destruction, and allowing

them to reach their breeding-grounds in sufficient numbers. But still there has been a great deal of surreptitious violation of the laws by itinerant fishermen, whose depredations can only be prevented by the people in the immediate neighborhood by assisting in enforcing the law; for it may here, we think, be pertinently remarked, that the 'American citizen,' whilst exhibiting the highest order of natural ability for the making of laws, seems to almost entirely overlook the fact that it is also his privilege and duty, individually, to aid in the enforcement of them.'

This lack of support on the part of the public in the enforcement of just and necessary fishery laws is not confined to the United States; but the view, at one time prevalent, that the product of the waters is common property which any one may secure how, when, and where he likes, is slowly giving way to one more enlightened and having more regard to the public interest.