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Report of the causes of the June mortality Kellys Pond Hatchery Prince Edward Island

by

R. H. M'Gonigle

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REPORT ON THE CAUSES OF THE JUNE MORTALITY, KELLYS POND HATCHERY, PRINCE EDWARD ISLAND.

by

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In June, 1933, a request was received at the Atlantic Biological Station for an investigation into the causes of an increased mortality, which was affecting particularly, the native trout fry, being carried in the Kelly's pond hatchery at that time.

It was not possible for such an investigation to be made by the Pathologist, at the time; however, Dr. A. W. H. Needler, Oyster Investigator at Prince Edward Island, was able to visit the hatchery, to ascertain as much as he could of the conditions.

A study of mortalities for this hatchery over a three-year period had revealed that an increase in the month of June was an annual occurrence, although the severity varied from year to year. While it was not feasible to visit the hatchery in 1933, plans were made for an investigation at approximately the corresponding period in 1934.

This hatchery is located on a small spring-fed stream, Kelly Brook, approximately a mile south of Southport, and three or four miles from Charlottetown. A large pool, about 180 feet, by 670 feet, has been formed by a dam, some twelve feet high. The intake for the hatchery water supply is located about five feet below the surface. The dimensions of the pond are illustrated in two figures, figure 1, and figure 2.

Some of the springs supplying the pool arise into the bottom of it, while the more important (larger) ones are situated more or less closely to it, along the brook, entering the south-eas (upper) end.

About four years ago, a very large fox-ranch was located on property abutting on the hatchery pool and the feeder brooks. These details are also illustrated in figure 1.

To make the investigation this year, the hatchery was reached Wednesday morning, June 6, 1934. A general inspection was first made, including the hatchery, the pond, and the sources. A more detailed investigation of the various parts followed, and included the taking of temperatures, and oxygen and acidity (pH---colourimetric) determinations.

Conditions at this hatchery had been studied previously on January 20, 1931, by the pathologist, on June 27, and again on July 25, in 1933 by Dr. Needler. With the exception of June 27, oxygen and acidity values were obtained on each of these occasions.

The following table (1) gives the values secured each time:

TABLE I.

Part Investigated	Data, for the year 1931 January	1933 July	1934 June
TEMPERATURE:			
In Hatchery trough-head			15.5 °C
foot	3.2 °C	73-68 °F.*	15.5
Pond-surface		(23 °C.)	15.5
bottom			
Brook-upper end			9.0
lower end			
Spring			8.0
pH:			
In Hatchery trough-head		9.4	10.0
foot	6.8	9.4	10.0
Pond-surface		9.4	10.0
bottom			6.8
Brook-upper end			6.8
lower end			10.0
Spring			6.8
House		6.8	
OXYGEN VALUES:	c.c. per l. / sat. %	c.c. per l. / sat. %	c.c. per l. / sat. %
In Hatchery trough-head	6.5 / 70	10.9 / 180	8.74 / 125
foot	6.9 / 74	10.1 / 167	8.17 / 117
Pond-surface		8.77 / 145	9.46 / 135
bottom		above values taken at 3:30 p.m.	
Brook-upper end			7.32 / 81
lower end			
Spring	at 9:30 p.m., 8.30 cc per l.- 137%.		6.92 / 76

*Temperature values taken from the hatchery records, for the date of visit.

As mentioned above, the record of the mortalities for this hatchery, over a three-year period, had revealed that, about the same time each year, an increase of mortality had occurred. These mortalities, for the various species being carried through this time, have been tabulated. The value indicating the mortality is the percent loss of the population-on-hand at the commencement of each week. That the corresponding periods for each year might be more easily compared, each week has been indicated by a number, determined by the date that Saturday occurs. Thus, week 32 is for any week of which the Saturday occurs between May 31 and June 6.

Two mortality tables have been prepared, one for the speckled trout (Table II), and the other for the salmon (Table III). Other groups or species were carried, but usually not throughout the whole time, so that their comparative value for the present purpose is less, especially as the same groups, or species did not appear in each of the years under consideration.

TABLE II

MORTALITY OF NATIVE (P.E.I.) SPECKLED TROUT.
Percent Loss, per Week.

(I) Weeks ending.	(II) Week No.	(III) 1931	(IV) 1932	(V) 1933	(VI) 1934
Apr. 5-11	24	0.580 H	0.318 H	0.533	0.109 H
12-18	25	0.375 H	0.203 H	0.788 H	0.306 H
19-25	26	0.712 H	0.577	0.531 H	0.428 H
26-May 2	27	0.461 H	0.977	0.990	0.590
May 3- 9	28	0.504 F	0.189	4.53	0.183
10-16	29	0.295 F	0.244	0.431	0.272
17-23	30	0.189 F	0.652	0.565	0.369 F
24-30	31	2.07	1.65	0.335 F	0.261 F
31-June 6	32	1.57	0.566	0.898	1.61
June 7-13	33	3.89	17.5	3.29	2.09
14-20	34	20.2	4.57	24.6	4.38
21-27	35	28.4	4.55	45.8	1.91
28-July 4	36	2.05	17.9	24.3	1.46
July 5-11	37		14.0	11.2	1.05
12-18	38			2.52	1.51

In the above table, the initials, H signify hatching, and F. feeding. The underline indicates mortalities exceeding 1.00 per cent.

TABLE III

MORTALITY OF NATIVE ATLANTIC SALMON
Percent Loss, per Week

(I) Weeks ending.		(II) Week No.	(III)	(IV)	(V)	(VI)
			Year			
			1931	1932	1933	1934
Apr.	5-11	24	0.332	9.450	0.239	0.120
	12-18	25	0.427	0.446	0.300	0.184
	19-25	26	1.01	2.01	0.482	0.466
	26-May 2	27	0.240	1.04	1.06	1.65
May	3- 9	28	0.953	1.10	0.965	1.31
	10-16	29	0.402	0.698	1.58	1.83
	17-23	30	0.239	0.317	0.708	0.806
	24-30	31	0.521	0.433	0.506	1.63
	31-June 6	32	1.34	0.936	0.468	1.84
June	7-13	33	4.07	2.80	0.975	0.740
	14-20	34	11.0	3.55	1.18	2.40
	21-27	35	9.03		1.01	1.16
	28-July 4	36	0.919		3.38	3.59
July	5-11	37			4.76	3.86
	12-18	38			5.97	
	19-25	39			4.61	

A glance at Table II will reveal that the mortality increase among the speckled trout has tended to commence suddenly, but in different weeks in each of the four years tabulated, although the thirty-first and thirty-third weeks seem to be the extremes. The increased loss in the salmon (Table III) seems to have been somewhat later. The loss in the trout usually reaches far greater proportions than in the salmon. This last fact has directed attention particularly to the trout.

The occurrence of this phenomenon at almost an identical period annually, at first suggested a correlation between a developmental phase, and some unfavourable condition existing at the hatchery; either all the time, and showing its influence when some physiological stress (?) arose (see below); or else, the unfavourable condition developed at this same period each year. Since however, the increased loss was not confined to any one group or species, nor was it confined to any particular part of the plant, there seemed to be very strong evidence that the water supply was contaminated.

TABLE IV

WEEKLY MAXIMUM AND MINIMUM TEMPERATURES (F.)

Weeks ending.	Week No.	1931 H	1931 L	1932 H	1932 L	1933 H	1933 L	1934 H	1934 L
Apr. 5-11	24	38	32	36	33	36	32	36	32
12-18	25	41	33	40	36	38	32	38	34
19-25	26	51	41	47	38	44	38	50	38
26-May 2	27	48	40	49	39	46	40	51	40
May 3- 9	28	54	41	48	42	54	42	54	42
10-16	29	50	44	57	44	52	44	54	42
17-23	30	68	45	58	51	56	46	48	42
24-30	31	69	52	54	47	57	52	55	48
31-June 6	32	62	50	60	48	60	50	66	52
June 7-13	33	62	54	65	51	66	58	62	52
14-20	34	67	58	64	53	66	58	60	52
21-27	35	65	58	65	58	62	53	66	52
28-July 4	36	70	54	67	60	74	60	70	60
July 5-11	37	70	63	66	60	72	62	71	54
12-18	38	68	61	66	60	72	62	74	64
19-25	39	75	60	68	61	74	67	78	66

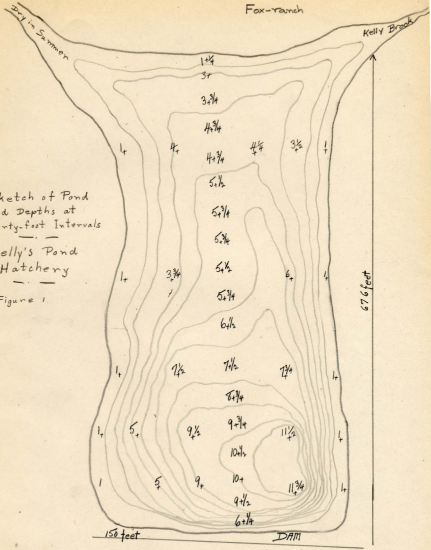
In order to check upon the possibility of developmental conditions being a responsible factor in this mortality, or an important contributory one thereto, another table (IV) was prepared, showing the maximum and minimum temperatures for each week. This has revealed a correlation between the onset of increased losses, and the temperatures. It will be observed that in each year, the losses began to increase usually in the week (or the week following) that in which the temperature (minimum) reached 50 F. This fact will account, in some degree (if not entirely) for the different week of onset in successive years. In this connection, the year 1932 is very interestint, for it will be observed that the temperature (minimum) reached 51 F during the thirtieth week, and corresponding therewith is an increased loss (Table II), which loss decreased with the drop in temperature for the next week, only to rise again with the rist of the temperature.

This particularly emphasizes the close relationship of the temperature to these losses. The fact that 50 C. appeared to be the critical temperature, at once suggested a possible connection with the change of metabolism which occurs at this temperature in speckled trout (M'Gonigle, p. 119), and it was thought that this might be the "physiological stress" referred to above.

The above outline presents a picture of conditions up to the investigation of June 1934. The most striking observation from the study was the peculiar pH, which indicates a strong increase of alkalinity. The same phenomenon was discovered the previous summer by Dr. Needler, although the alkalinity in July was not so great, possible indicating the first steps of a return to normal (see below).

Next, considering the other factors, the high oxygen concentration of the lower pool, and in the hatchery is of interest. It may be explained by the fact that there was bright sunlight, and an abundance of algae which floated up to the surface of the pool, full of gas bubbles of oxygen, produced by the photosynthesis of the plants. This gas increased the saturation of oxygen from 76% in the spring, and 81% in the brook, to 135% on the surface of the pool, at the dam. The fall of the water into the various troughs inside the hatchery reduced this latter value somewhat, to 125%. Dr. Needler, the previous summer, in late July, secured still higher values, namely to 180% saturation. Under such conditions, high oxygen values are usual, but seem to be entirely harmless (Wiebe and McGavock, p.267). It is improbable that this high concentration of oxygen should have any share in the increased losses.

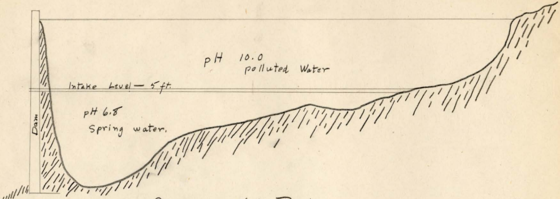
The temperature range at this hatchery is one of the most favourable type, as the spring-water supply tends to prevent extremes both summer and winter, and also to dampen all tendencies to wide fluctuations, diurnal as well as seasonal.



Sketch of Pond and Depths at Forty-foot Intervals

Kelly's Pond Hatchery

Figure 1.



Contour of Kelly's Pond
taken through deep channel — see figure 1.
Level of Intake Pipe shewn by
Double Line,

FIGURE 2.

The increased alkalinity (pH) from the normal 6.8 to the high figure of 10.0 is probably significant, and seems to postulate the presence of a highly dissociable (strong) alkali. The figure of 6.8 represents the normal hydrogen-ion concentration of this water-system, as can be seen by reference to Table I. It is the value found in the hatchery, during the winter (1931) and in June (1934) in the brook and springs supplying the water, the springs rising into the bottom of the pool, as well as those supplying the brook on the surface. Dr. Needler also secured this value for the water supply in the Superintendent's house, in July, 1933; and states furthermore, that it is the same as the value found for the Bideford river, Malpeque bay, P. E. I.

Samples of the surface water, taken from a boat, throughout the length of the Kelly Brook, were uniformly 6.8, down to the level of the pool, where the still water was first reached, and there the figure jumped at once to 10.0. The first clumps of algae were also observed in the pool at this point, where the water became still, as the brook widened out into the pool. This is indicated in figure 1, by the 'B' of Kelly Brook. Large masses of decomposing algae were rising up to the surface, buoyed up by gas bybbles, and floated out over the dam. In the pool, the value of 6.8 was also found when samples were secured below the level of the intake pipe (figure 2), that is below five feet. This seems to indicate that uncontaminated, spring water filled the bottom of the pool, and the up-welling water from these springs was mixing with the down-flowing impure water at the intake. This fact is probably significant in relation to the stock of trout maintained above the dam, in this pool.

It has been known for some time tht algae of various kinds when present in large amounts may have very harmful influences on fish life, the action varying with the type of alga. The blue-green algae especially seem to have deleterious effects. This may be due to the formation of toxic pretein decomposition products, such as hydroxylamine (G. W. Prescott, p. 76). The chemical (structural) formula of this substance is $H_2.n.OH$. If this formula be compared with that of ammonia $H_2.N.H$, a strong chemical resemblance is obvious. Ammonia is a very powerful poison, very soluble in water and produces a very marked alkalinity in solution, second only to that of the alkalis themselves. Hydroxylamine has many of these properties of the parent substance, but is even more poisonous. Quaternary nitrogenous bases (from pretein) are as strongly basic as potassium hydroxide.

The increase in alkalinity observed in Kelly's Pond, from 6.8 to 10.0 as already mentioned indicates a strongly dissociated, that is, a strong alkali. This agrees with the theoretical discussion in the previous paragraph.

This increase of alkalinity of waters full of algae under the influence of photosynthesis is a well-known phenomenon, and some algae have greater action than others. The usual explanation offered is that the carbon dioxide (carbonic acid gas) is removed from the water by the plants under the action of sunlight to form their food materials, at the same time liberating the free oxygen, which buoys up the algae, and gives the high ox ygen values found in the pool.

Since carbon dioxide in solution gives an acid value to water, slight it is true, its removal will permit any basis substances present to exert their influence, and in many natural waters this basic substance is calcium (lime), and a pH of 9.0 is common (Wiebe, p. 136; Irving, p. 162; Smith, p. 317). In the present case, this basic substance may be hydroxylamine or perhaps some quaternary nitrogenous base, which bases form many of the most poisonous substances we know. On account of chemical difficulties, it has not been possible to demonstrate the existence of this (or similar) compound, but decomposition of algae is being attempted experimentally, and the resulting fluids will be tested on fish for toxicity. As there is no photosynthesis taking place in this experiment, the carbon dioxide is accumulating, and the acidity is less than pH 7.0----it has not gone to pH 10.0 as in Kelly's pond. The alga being used in the experiment was sent over by Superintendent Haley, who advised us that the particular form observed at the time of the investigation had disappeared, and was replaced by another, which he sent in place.

The probable sequence of events associated with the mortality may be now set forth, as it appears to the writer. Following the warming of the water in the spring-time, particularly as the water during the winter was several degrees warmer than freezing, there resulted a rich growth of algae, presumably Cyanophyceae (Blue-green). There may also exist a fertilization of the pond from the effluent from the fox-ranch which however, seems unlikely because of the care used there to safeguard the animals. The algae continue to develop until the temperature of 50 F. is reached, and then they commence to decompose, liberating the poisonous nitrogen bases, and other protein break-down materials, among which is possibly hydroxylamine. Under the influence of sunlight, and strong photosynthesis of the algae, the withdrawal of carbon dioxide in the presence of these strong organic bases makes the pH rise to very high levels. The fact that water of the normal (usual) pH value is found above and underneath the zone of high pH seems to be definitely indicative of the addition of some substance, toxic in nature to the water above the five-foot level, and below the entry of the brook water---a region already mentioned as that in which the algae are first observed.

This is believed to be the cause of increased losses at this time of year, and the variation in severity as between years can be interpreted as a variation in the quantity of the alga grown.

It is recommended that the pool be drained completely, as early in the summer as possible, and left fallow as long as possible. The following May, an algacide should be added to the water to destroy any algae which may start to grow from the spores left in the soil of the bottom. It might be feasible to lime the pool bottom at a rate of one for per acre of bottom when the pond is drained, but the danger to fish life below makes this a dubious method, unless the lime could be left for several weeks to be neutralized. Could this be done, the employment of an algacide in May could be reserved for an emergency, for the use of such a chemical, usually copper sulphate, when the hatchery is full of young fish would also be a delicate operation.

Apparently no means of draining the pool was built in when the dam was constructed, but as it is so important to drain the pool to clear up this condition, it is recommended that such be put in at once.

From the diagram, figure 1, it was calculated that the volume was approximately two and a quarter thousand cubic feet, corresponding roughly to one and a half million Imperial gallons of water. The rate of flow was estimated early in July as about one hundred and fifty gallons per minute. The rough rule for finding volume, namely acres x depth ÷ 3 = y million gallons gave a result of two and three quarter million gallons (probably 2 1/5 million Imperial gallons). Hence 15 pounds of copper sulphate dissolved from a boat on the surface, and 5 pounds in Kelly Brook, and 5 pounds suspended six to ten feet from buoys in the spring water below the level of the intake would probably be sufficient to rid the pool of algae. This is calculating a dose of one part per million. It is possible that half this dose would do, but if the fish could stand the higher dose, it is recommended. In any event tests on the fish with baths of this concentration should certainly be tried first, and if toxic, the smaller dose would probably be effective.

It is believed that if these recommendations be carried out, the annual June loss will be completely prevented.

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