

CA20N
WR 505
1964
F43



THE
ONTARIO WATER RESOURCES
COMMISSION

REPORT ON

A STUDY OF THE FLAVOUR OF FISHES

from

LAKE ST. LAWRENCE, ST. LAWRENCE RIVER AND LAKE ST. FRANCIS



Copyright Provisions and Restrictions on Copying:

This Ontario Ministry of the Environment work is protected by Crown copyright (unless otherwise indicated), which is held by the Queen's Printer for Ontario. It may be reproduced for non-commercial purposes if credit is given and Crown copyright is acknowledged.

It may not be reproduced, in all or in part, for any commercial purpose except under a licence from the Queen's Printer for Ontario.

For information on reproducing Government of Ontario works, please contact ServiceOntario Publications at copyright@ontario.ca

ONTARIO WATER RESOURCES COMMISSION

REPORT

On

A STUDY OF THE FLAVOUR OF FISHES

From

LAKE ST. LAWRENCE, ST. LAWRENCE RIVER AND LAKE ST. FRANCIS

May, 1964

By

Yvonne H. Swabey

Biology Branch

Div. of Laboratories

July, 1964

SUMMARY

In co-operation with the Ontario Department of Lands and Forests, in May, 1964, personnel of the Ontario Water Resources Commission made a series of panel tests to determine the presence or absence of foreign flavour in several species of fish collected from the St. Lawrence River upstream and downstream of Cornwall.

The results of the taste tests indicate that the river water in the vicinity of Cornwall imparted a taint to the flesh of a large percentage of fish of several species that, while the frequency and intensity of the taint declined downstream, considerable impairment of flavour occurred for at least 13 miles.

Within these 13 miles the order of decreasing frequency of foreign flavour among the species was: carp, suckers, perch, bullheads and pike.

Of six odours presented for comparison, wastes from the Domtar Pulp and Paper Company plant at Cornwall were deemed to resemble the foreign flavour in fish most closely.

The threshold odour of a river water sample collected approximately one mile downstream of Cornwall was at least twice the values determined for three locations up to 19 miles further downriver.

A STUDY OF THE FLAVOUR OF FISHES

From

LAKE ST. LAWRENCE, ST. LAWRENCE RIVER AND LAKE ST. FRANCIS.

In October, 1963, taste tests were run in the Ontario Water Resources Commission laboratories on smoked carp from Lake St. Francis which had been rejected by the Harbord Fish Company, Toronto, on the basis of an undesirable foreign flavour. Results of the tests (reported December, 1963) indicated a high incidence of foreign flavour in the Lake St. Francis fish when compared with carp from Lake Ontario. In order to determine whether a foreign flavour was present in other species and in adjacent areas of the St. Lawrence River, an additional series of taste tests was planned in co-operation with the Ontario Department of Lands and Forests.

The tests included five species of fish from five locations but every species was not available from each location. Foreign flavour in fish was compared with the odours of various industrial wastes entering the river at Cornwall and with water having the odour of natural aquatic vegetation. Threshold odours of water samples from four locations were determined. The results obtained from these additional tests are presented in this report.

ACKNOWLEDGEMENTS

The Commission wishes to acknowledge the assistance of Mr. N. D. Patrick, Assistant District Forester, Mr. M. J. Martin, Conservation Officer and Mr. H. McLeod, Biologist, of the Ontario Department of Lands and Forests, Kemptville, in procuring the fish for testing, and of Mr. T. W. Dwight, Supervisor of Mensuration and Statistics, Research Branch, Maple, in reviewing the data.

We wish to thank also personnel of Canadian Industries Limited, Courtauld's Limited and the Howard Smith Division of Dominion Tar and Chemical Company, all of Cornwall, for their co-operation in supplying samples of their industrial wastes.

AREA STUDIED

The area included by the fish flavour study extended from Mille Roches Island in Lake St. Lawrence, downstream to Pointe Mouillée on the north shore of Lake St. Francis. Locations sampled within the area are indicated on the sketch map enclosed with this report. On the map and throughout the report these stations are designated by river mileages upstream from the Ontario-Quebec boundary. Thus, fish were collected from Stations 34.7 (Mille Roches Island) 33.7, 22.3, 15.9, 10.1 and 3.0 (Pointe Mouillée Bay.)

METHODS AND PROCEDURES

Threshold Odour of River Water

Samples of surface water were collected by Mr. M. J. Martin, Conservation Officer, from Stations 22.3, 15.9, 10.1 and 3.0 on March 23, 1964. These samples were shipped by Railway Express and arrived at the Commission laboratory in Toronto on March 25. They were stored at 8°C in a laboratory refrigerator.

Tests for threshold odours were made on March 26 and March 31, in an unused, air-conditioned room. All glassware was washed with non-perfumed detergent and rinsed with odour-free water obtained by passing tap water through activated carbon. Samples were diluted with odour-free

water to 200 ml. and heated to $60 \pm 2^\circ\text{C}$ in stoppered flasks according to standard procedure (A.P.H.A., 1960). Dilutions of the samples were presented at random with a known flask of odour-free water comparison. Series of dilutions of a given sample were presented at from three to six separate sessions. The panel of judges consisted of five persons on the staff of the laboratory.

Threshold odours for each panelist were obtained by noting the dilution number of the lowest concentration where odour was detected. Medians and geometric means were calculated from these. In two instances where indefinite results were obtained, calculations were made on the thresholds of four panelists rather than five.

The Taste Panel

The panel consisted of six staff members, three men and three women, who professed no dislike for fish and could attend the testing sessions regularly. Non-smokers constituted two-thirds of the panel. A spare judge took part in two tests when another person was not able. Only two panel members had had experience in fish taste tests, but all participated in a preliminary "warm up" test in which bullheads from the test area were used. All evinced an interest in the tests and approached their duties seriously. In addition to the test procedure they were told only that they would be tasting several kinds of fish from different locations and that the object of the tests was to determine whether foreign flavour existed in some fish and not others. None of the panelists knew the fish collection locations nor the order in which the samples were presented.

Procurement of Fishes

The fish collections were made under the direction of Mr. N. D. Patrick, Assistant District Forester, Ontario Department of Lands and Forests, Kemptville, during the period February 18 to April 30, 1964. The objective was to obtain 12 individuals of each of several species from locations upstream and downstream of Cornwall. Collections consisting of four to 12 individuals of six species were obtained from the stations as indicated by an X in the following chart:

<u>Location</u>	<u>Bullheads</u>	<u>Perch</u>	<u>Pumpkinseeds</u>	<u>Suckers</u>	<u>Pike</u>	<u>Carp</u>
34.7	X	--	--	X	X	X
33.7	--	X	--	--	--	--
22.3	X	X	X	X	X	--
15.9	--	--	--	X	X	--
10.1	X	X	X	X	X	X
3.0	X	X	X	--	--	--

The fish were prepared as for market* and placed in heavy plastic bags. Each bag contained one species from one location and was suitably labelled. The fish were maintained in a freezer until transported to the Commission laboratory by car. One shipment was received on March 18, another on April 30. All fish were in a frozen condition when received. Due to the volume of fish involved, the bagged samples were stored in a frozen food locker in Toronto until the day before they were tested.

*Bullheads: skinned eviscerated, heads off
Perch: as caught
Suckers: as caught
Pike: as caught
Carp: eviscerated, heads off
Pumpkinseeds: as caught.

Preparation of Fish Samples

The fish were thawed usually overnight in the refrigerator at 8°C. In the case of very large species they were allowed to thaw for a few hours at room temperature before being placed in the refrigerator.

Samples were normally taken within three hours before each test. Each sample consisted of a fillet cut from the meatiest part of the fish, between the mid-dorsal and lateral lines. Skin was removed but in some species the presence of small bones could not be avoided. According to Baldwin et al. (1962), bone inclusion does not significantly influence the acceptability of fish flesh. Samples were placed in individual plastic bags, labelled, and returned to the refrigerator until sampling for the test was complete. Occasionally it was necessary to hold thawed fish for a test the next day. Whenever time permitted, samples, rather than the whole fish, were held overnight in labelled plastic bags under refrigeration. In either case fish from all locations were treated similarly.

Approximately 40 minutes before test time the fish samples were taken from the refrigerator and three sub-samples of about one cubic inch were cut from each. The sub-samples were placed in individual, new aluminum foil baking cups and covered tightly with numbered pieces of heavy-duty aluminum foil. No condiments were added, nor used during the tests. The numbers corresponded to those on a chart of the order of presentation of samples. Careful attention was paid to the proper dispensation of the sub-samples. Samples and sub-samples were prepared exclusively by the author.

The cups of fish, on enamelled trays, were baked in an oven at 350°F for 15 minutes. The baking method, rather than frying, was chosen

to prevent the introduction of extraneous flavours. Baked samples were taken to the test room where they were kept warm under a heat lamp for a maximum of twenty minutes.

The Taste Tests

The taste-testing sessions were held during the period May 5 to May 14, 1964, in an air-conditioned room which is usually unoccupied. The tests were scheduled once or twice daily at least one hour after meals and included 11 sessions in addition to the preliminary "warm up". All glassware used had been washed with non-perfumed detergent and rinsed with taste-free water produced by passing tap water through activated carbon. Panelists were asked to refrain from smoking for half an hour before each test. Women judges were asked not to use perfume and to remove their lipstick before tests. All panelists washed their hands with "Ivory" soap before handling the samples.

"Place-settings" for the judges were positioned on the laboratory benches so that one person did not face another directly, nor sit next to another. Each judge kept the same position throughout the tests.

The place-setting for each panelist consisted of a dish of unsalted soda crackers, a waste container, a fork, a paper cup, a data sheet and a flask of rinse water. The latter was diluted lemon juice (2 tablespoons per quart taste-free water) at room temperature as suggested by Baldwin et al. (1961). In tests where odours were given for comparison, six numbered, brown-glass bottles of liquids at room temperature were included in the setting.

Each panelist was presented with a sample of warm fish marked "Blank" to acquaint him with the flavour of the species, and from five to

eight samples identified by number only. He was instructed to chew the "Blank" fish, chew a soda cracker and rinse his mouth with the rinse-water, placing all waste in the container provided. He was then to taste each of the numbered fish samples in turn, chewing a cracker and rinsing after each and recording the presence or absence of a foreign flavour and its intensity as follows:

o	absent
+	barely perceptible
++	definite
+++	strong

When three tests had established that foreign flavour was present in some of the fish, the panelists were asked in subsequent tests to compare foreign flavour rated definite or strong with the six odours presented. They did this when all fish samples had been tasted to prevent interference with their tasting ability. If the foreign flavour resembled the odour of a liquid presented, the panelist recorded the number of the bottle, or bottles, on his data sheet. The contents of the bottles and their sources were as follows (wastes with powerful odours were diluted with odour-free water to reduce the intensity somewhat):

- No. 1. Stove oil from Domtar, Cornwall; diluted.
- No. 2. Water from jar of Chara and other aquatic plants.
- No. 3. Total waste from Domtar, Cornwall; diluted.
- No. 4. Total waste from Canadian Industries Limited, Cornwall.
- No. 5. Digester relief gas condensate from Domtar, Cornwall; diluted.
- No. 6. Sulphide waste from Courtauld's, Cornwall.

Only one species of fish was used during a given test. All fish used for "Blank" samples were from Station 34.7 or 33.7 in Lake St. Lawrence. The general plan of sample presentation in a test involved the tasting of four fish from each location (including Lake St. Lawrence), each fish being

tasted by three persons. Due to the variation in the numbers of specimens available, four from each location could not always be included, but at least one unknown sample of Lake St. Lawrence fish was presented in every series. The order of presentation of samples from the various collection sites was changed for each test.

Numbers of individual fish tested were as follows:

<u>Station</u>	<u>Bullheads</u>	<u>Suckers</u>	<u>Perch</u>	<u>Carp</u>	<u>Pike</u>
34.7	6	6	--	12	10
33.7	--	--	12	--	--
22.3	6	10	9	--	6
15.9	--	10	--	--	4
10.1	6	4	12	12	12
3.0	6	--	--	--	--

The pumpkinseed collections were not used as this species was not available from Lake St. Lawrence for comparison. Through an oversight, the perch from Station 3.0 were not included in the tests.

Sub-samples, hereafter referred to as "samples", totalled 456 and represent 143 individual fish.

Treatment of Data

Frequency and intensity of foreign flavour in the samples were tabulated by species and sampling location. Since there was no significant difference in the incidence of foreign flavour between the perch collected at Station 33.7 and the other species taken from Station 34.7, both in Lake St. Lawrence, data for perch were included with those from Station 34.7.

In order to determine whether apparent differences in the data were statistically significant, they were tested both by analysis of variance and a chi-square test. Analyses of variance were made by methods given by Snedecor (1956) using an arcsin transformation for proportions. Where it was necessary to estimate a missing datum, corrections for bias were made as directed. Chi-square values were obtained by a formula for data arranged in two classes (+ and -) given in Snedecor (loc. cit.) and illustrated more fully in Cochran and Cox (1962, pg. 103-105). Corrections for continuity were made in all 2 x 2 tables.

RESULTS AND DISCUSSION

Threshold Odour of River Water

The threshold odour values determined for samples of water from the St. Lawrence River-Lake St. Francis area are given in Table 1. These values represent the highest dilutions of the samples where odour was detected.

Table 1. Threshold odour values of river water samples.

Station*	Threshold Odour	
	Median	Geometric Mean
22.3	60.0	57.1
15.9	29.5	26.6
10.1	20.5	18.5
3.0	24.0	25.9

*Miles upstream from the Ontario-Quebec boundary.

The geometric mean thresholds ranged from 18.5 at Station 10.1 to 57.1 at Station 22.3. The data indicate that an odour would be detectable in water from Station 10.1 if it were diluted 18.5 times, from Station 3.0 diluted 25.9 times, from Station 15.9 diluted 26.6 times, and from Station 22.3 diluted 57.1 times.

Foreign Flavour in Fish

Incidence in Samples

Data on the incidence and intensity of foreign flavour in fish samples as determined by the panel are given in Table 2. The table includes the total number of samples of each species rated positive for foreign flavour at each location and the total number placed in the definite or strong categories combined. Table 3 presents the basic data in Table 2 in percentages of the number of samples presented. Note that the percentage of positive samples rated as barely perceptible, definite or strong at each location is given also.

Reference to Table 2 shows that of 144 samples from Station 34.7, 35 were rated positive for foreign flavour and 11 of these classed as definite or strong. These figures represent overall percentages of 24.3 positive and 7.6 definite or strong. Among the five species tested from this station, the percentage of definite or strong foreign flavour ranged from 0.0 in suckers to 16.6 in carp.

A total of 91 of the 102 samples from Station 22.3 evinced foreign flavour, with 78 rated as definite or strong. Overall incidence at this station was 89.2 per cent positive, 76.6 per cent definite or strong. Occurrence of definite or strong foreign flavour among the four species

tasted ranged from 50.0 per cent in the pike to 93.3 per cent in the suckers.

Of the 42 samples of suckers and pike from Station 15.9 presented to the panel, 35 or 83.3 per cent were rated positive, 20 or 47.6 per cent definite or strong. Definite or strong foreign flavour occurred in 33.3 per cent of the pike samples and in 53.3 per cent of the sucker portions.

At Station 10.1, 79.2 per cent of the 144 samples given were judged positive, 50.0 per cent placed in the definite or strong foreign flavour categories. Among the five species tested from this location the incidence of definite or strong foreign flavour ranged from 29.2 to 44.4 per cent with the exception of the carp which exhibited an incidence of 88.8 per cent.

Although 54.2 per cent of the 24 samples from Station 3.0 bullheads were rated positive by the panel, only 12.5 per cent were classed as definite or strong.

The data in Tables 2 and 3 show that the overall incidence of foreign flavour increased from Station 34.7 to Station 22.3 then decreased progressively at Stations 15.9, 10.1 and 3.0. Statistical analyses of the data indicated that the total numbers of positive samples at Stations 22.3, 15.9 and 10.1 were significantly higher than the total incidence at Station 34.7. Moreover, the occurrence of foreign flavour in each species was significantly higher at Stations 22.3, 15.9 and 10.1 than it was at Station 34.7. The bullheads from Station 3.0 did not differ significantly from those at Station 34.7 in this respect.

Table 2. Incidence and intensity of foreign flavour in fish samples.

Station	Fish Species	Number of Samples	Number of Samples				Total	
			0*	+	++	+++	Positive	Definite or Strong
34.7	Bullheads	18	12	4	2	0	6	2
	Suckers	24	21	3	0	0	3	0
	Perch	36	28	7	1	0	8	1
	Carp	36	26	4	2	4	10	6
	Pike	30	22	6	1	1	8	2
	Totals	144	109	24	6	5	35	11
22.3	Bullheads	24	2	4	11	7	22	18
	Suckers	30	0	2	9	19	30	28
	Perch	30	1	6	16	7	29	23
	Pike	18	8	1	9	0	10	9
	Totals	102	11	13	45	33	91	78
15.9	Suckers	30	4	10	9	7	26	16
	Pike	12	3	5	2	2	9	4
	Totals	42	7	15	11	9	35	20
10.1	Bullheads	24	6	11	3	4	18	7
	Suckers	12	3	4	5	0	9	5
	Perch	36	7	13	10	6	29	16
	Carp	36	0	4	7	25	36	32
	Pike	36	14	10	8	4	22	12
	Totals	144	30	42	33	39	114	72
3.0	Bullheads	24	11	9	3	1	13	4

*Foreign flavour intensity ratings: 0 absent
+ barely perceptible
++ definite
+++ strong.

Table 3. Percentage incidence of foreign flavour in fish samples.

Station	Fish Species	Number of Samples	Percentage of Samples				Percentage Definite or Strong	
			0*	+	++	+++	Positive	Strong
34.7	Bullheads	18	66.7	22.2	11.1	0.0	33.3	11.1
	Suckers	24	87.5	12.5	0.0	0.0	12.5	0.0
	Perch	36	77.8	19.4	2.8	0.0	22.2	2.8
	Carp	36	72.2	11.1	5.6	11.1	27.8	16.7
	Pike	30	73.3	20.0	3.3	3.3	26.7	6.7
	All species	144	75.7	16.7	4.2	3.5	24.3	7.6
Percentage of total positive:			68.6	17.1	14.3			
22.3	Bullheads	24	8.3	16.7	45.8	29.2	91.7	75.0
	Suckers	30	0.0	6.7	30.0	63.3	100.0	93.3
	Perch	30	3.3	20.0	53.3	23.3	96.7	76.7
	Pike	18	44.4	5.6	50.0	0.0	55.6	50.0
		All species	102	10.8	12.7	44.1	32.4	89.2
Percentage of total positive:			14.3	49.5	36.3			
15.9	Suckers	30	13.3	33.3	30.0	23.3	86.7	53.3
	Pike	12	25.0	41.7	16.7	16.7	75.0	33.3
		All species	42	16.7	35.7	26.2	21.4	83.3
Percentage of total positive:			42.9	31.4	25.7			
10.1	Bullheads	24	25.0	45.8	12.5	16.7	75.0	29.2
	Suckers	12	25.0	33.3	41.7	0.0	75.0	41.7
	Perch	36	19.4	36.1	27.8	16.7	80.6	44.4
	Carp	36	0.0	11.1	19.4	69.4	100.0	88.9
	Pike	36	38.9	27.8	22.2	11.1	61.1	33.3
	All Species	144	20.8	29.2	22.9	27.1	79.2	50.0
Percentage of total positive:			36.8	28.9	34.2			
3.0	Bullheads	24	45.8	37.5	12.5	4.2	54.2	16.7
Percentage of total positive:			69.2	23.1	7.6			

*Foreign flavour: 0 absent + barely perceptible ++ definite +++ strong.

Intensity

In regard to intensity of foreign flavour, the percentage incidences in Table 3 show an overall increase in both definite and strong categories in fish from Station 22.3 over the percentages recorded for Station 34.7. At Station 15.9 incidences in both of these classes decreased and that for barely perceptible foreign flavour increased. Slight decreases occurred in the overall percentages of barely perceptible and definite foreign flavour, and a slight increase in strong foreign flavour, at Station 10.1. The bullheads from Station 3.0 showed additional decreases in the definite and strong classes, an increase in barely perceptible foreign flavour. Although the overall percentages for the various stations could have been influenced by different species composition, chi-square tests using frequencies of the three intensities at Station 34.7 as expected values, indicated that the occurrence of both definite and strong foreign flavour was significantly greater at Stations 22.3, 15.9 and 10.1. The incidence of barely perceptible foreign flavour was not significantly different at Station 22.3 but was significantly higher at Stations 15.9, 10.1 and in the bullheads from Station 3.0. Neither definite nor strong foreign flavour in the latter was significantly different from that recorded at Station 34.7. Considering the overall incidence of definite and strong foreign flavour combined (Table 3), it will be noted that the figure obtained for Station 22.3 was approximately ten times that for Station 34.7, while the data for Stations 15.9 and 10.1 indicated a six-fold increase, for Station 3.0, two-fold.

Foreign flavour was found in 71.1 per cent of all samples of fish collected downstream of Cornwall, in 24.3 per cent of those taken upstream. Definite or strong foreign flavour was recorded for 55.8 per

cent of all samples from downstream stations, 7.6 per cent for all upstream samples.

Incidence in Individual Fish

Table 4 presents the percentage of individual fish tested which could be considered tainted. The criterion used for these data was a rating of definite or strong foreign flavour for at least two of the three samples presented.

Table 4. Percentage of individuals tainted. Data based on two out of three samples rated definite or strong for foreign flavour.

Station	Bullheads		Suckers		Perch		Carp		Pike		All Species	
	%	N*	%	N	%	N	%	N	%	N	%	N
34.7	0	6	0	6	0	12	8	12	0	10	2	46
22.3	67	6	100	10	89	9	--	--	50	6	81	31
15.9	--	--	60	10	--	--	--	--	25	4	50	14
10.1	17	6	25	4	33	12	92	12	25	12	44	46
3.0	0	6	--	--	--	--	--	--	--	--	0	6
22.3)												
15.9)	42	12	71	24	57	21	92	12	32	22	57	91
10.1)												

*N = Number of fish tested.

The final column in the table shows that the percentage of individuals of all species considered to be tainted rose from 2 at Station 34.7 to 81 at Station 22.3 and declined subsequently to 50, 44 and 0 at Stations 15.9, 10.1 and 3.0, respectively.

Data for three locations downstream of Cornwall, 22.3, 15.9 and 10.1, are combined in the last line of Table 4. The overall percentage of tainted fish of all species in the three collections was 57, whereas

2 per cent occurred in the collections from Station 34.7 upstream. The percentage of tainted individuals of the various species ranged from 32 for pike to 92 for carp.

Species Differences

Variation in the incidence of foreign flavour among the fish species tested has been noted briefly in preceding paragraphs. In order to determine whether foreign flavour was significantly more prevalent in any of the species, data on the occurrence of definite or strong foreign flavour in samples from each station were subjected to chi-square tests. The data on samples, rather than those on tainted fish (Table 4), were used since the latter were based on a selected criterion.

Table 5 presents the percentage occurrence of definite or strong foreign flavour in samples from each station and in those from Stations 22.3, 15.9 and 10.1 collectively. For a given location, percentages not underscored by the same line are significantly different.

Table 5. Comparison of foreign flavour incidence in fish species from the same location. Percentages for a given location not underscored by the same line are significantly different at the 5% level.

Station	Percentage of samples with definite or strong foreign flavour				
	Carp	Suckers	Perch	Bullheads	Pike
34.7	<u>16.7</u>	0.0	2.8	11.1	6.7
22.3		<u>93.3</u>	<u>76.7</u>	<u>75.0</u>	50.0
15.9		<u>53.3</u>			<u>33.3</u>
10.1	88.9	<u>41.7</u>	44.4	29.2	<u>33.3</u>
22.3)	88.9	<u>68.1</u>	<u>59.1</u>	<u>52.1</u>	37.9
15.9)					
10.1)					

There was no significant difference in foreign flavour among the five species from Station 34.7. At Station 22.3, where foreign flavour was most extensive, incidence in suckers was significantly greater than in pike but not greater than that in perch or bullheads. No significant difference was found between the suckers and pike at Station 15.9 in this respect. The carp samples from Station 10.1 exhibited an incidence of foreign flavour significantly higher than that of suckers, perch, bullheads or pike from the same area.

Reference to the collective data in Table 5 for the three stations downstream of Cornwall indicates that flavour impairment occurred to the greatest extent in carp and in lesser degrees in suckers, perch, bullheads and pike. The incidence of foreign flavour in carp was significantly greater than that found in all other species, while the occurrence in suckers was greater than that in bullheads and pike. Perch samples exhibited a frequency of foreign flavour significantly greater than pike only.

Since the highest frequencies of foreign flavour were found in carp and suckers which are bottom-feeders, and the least in pike which are predators, the question arises as to whether the taint was associated with the feeding habits of the species and the benthic environment. When the total incidence of definite or strong foreign flavour in bottom-feeders (carp, suckers and bullheads) was compared with the total in perch and pike at a given location, a significantly greater incidence was found in the former at Stations 22.3, 10.1 and at Stations 22.3, 15.9 and 10.1 collectively. There was no difference, however, at Stations 34.7 and 15.9. This would tend to support the hypothesis that foreign flavour was associated with bottom-feeding. However, certain data in Table 5 are not compatible with this theory. At Station 22.3, where foreign flavour was most extensive

in all species, the incidence in perch, which are not notably bottom-feeders, was not significantly different from that in suckers and bullheads, which are. Moreover, the incidence in bullheads was not significantly different from that in pike, which are predators. The lack of significant differences among the suckers, perch, bullheads and pike at Station 10.1 is also noteworthy from this aspect. In addition, reference to the collective data for Stations 22.3, 15.9 and 10.1 shows that foreign flavour in bullheads was significantly lower than in the other bottom-feeders. The data suggest that in the length of river from Station 22.3 to Station 10.1 high incidences of foreign flavour were associated primarily with carp and suckers which are bottom-feeders, but not with all bottom-feeding species, nor with bottom-feeders only.

The natural flavour of carp is, apparently, less appealing in general than the flavour of other species. In a study of the flavour of fish from different sources, Baldwin et al. (1961) found that carp were consistently rated of poorer quality than pike by a taste panel. This reaction to carp may have influenced our data somewhat, as indicated by the tendency towards a higher incidence of foreign flavour in carp than was found in other species, from Station 34.7.

The flesh of bottom-feeders may acquire a "muddy" flavour. The complete lack of definite or strong foreign flavour in suckers and the low incidence in bullheads from Station 34.7 suggests that foreign flavour detected in these species downstream of Cornwall was not of natural origin.

Resemblance of Foreign Flavour to Odours

As noted earlier, panel members were asked to compare definite or strong foreign flavour in fish samples with the odours of six liquids. The odorous substances, numbered 1 to 6, were: stove oil from Domtar, water exposed to Chara and other aquatic plants, total waste from Domtar, total waste from C.I.L., digester relief gas condensate from Domtar and sulphide waste from Courtauld's. The numbers of fish samples with foreign flavour resembling the various odours are given in Table 6. The totals for each odour at the various locations have been converted to percentages based on numbers of samples presented in the upper part of Table 7. and percentages based on the number of samples with definite or strong foreign flavour in the lower portion.

The judges selected the odours of stove oil, Domtar total waste and Domtar digester relief gas condensate almost exclusively as those resembling the foreign flavour in the fish. The collective data for the three stations downstream of Cornwall indicate no significant differences among the frequency of these three odours. On the basis of numbers of samples presented, the frequency of selection of all three liquids from Domtar was significantly greater at Station 22.3, 10.1 and for the three downstream stations collectively than the frequencies recorded for Station 34.7. At Station 15.9 only the digester relief gas condensate incidence showed a significant difference, due possibly to the lower number of samples tested.

It will be noted that, although the overall occurrence of definite or strong foreign flavour was small at Station 34.7, the flavour of a large proportion of the samples so rated was deemed to resemble the odour of the total waste from the Domtar plant. All of these samples were of carp. In the study mentioned earlier, Baldwin et al. (1961) noted that taste panelists described the flavour of carp as "fishy" and "musty"

Table 6. Resemblance of definite or strong foreign flavour in fish to various odours.

Station	Species	Number of Samples	Samples Definite or Strong	Samples with flavour Resembling Odour:						Not Classed
				1**	2	3	4	5	6	
34.7	Suckers*	12	0	0	0	0	0	0	0	0
	Perch	36	1	0	1	0	0	0	0	0
	Carp	36	6	0	0	4	0	1	0	1
	Pike	30	2	0	0	0	0	1	0	1
22.3	Suckers	18	17	8	0	0	0	9	0	0
	Perch	30	23	10	0	7	0	6	0	0
	Pike	18	9	3	0	5	0	1	0	0
15.9	Suckers	18	10	1	0	2	0	3	1	3
	Pike	12	4	1	0	2	0	1	0	0
10.1	Perch	36	17	8	0	5	0	4	0	0
	Carp	36	32	11	1	9	0	11	0	0
	Pike	36	12	5	0	4	0	3	0	0

*Comparisons made in one test only.

**Bottle contents: 1. Stove oil, Domtar
 2. Chara water
 3. Total waste, Domtar
 4. Total waste, C.I.L.
 5. Digester relief gas condensate, Domtar
 6. Sulphide waste, Courtauld's.

regardless of whether they had been collected from a cold, deep lake, a warm, shallow lake, or from water receiving industrial effluents including pulp mill wastes. This observation and the results of our tests suggest that an unnaturally-produced musty flavour in carp downstream of Cornwall could have been enhanced by, or added to the naturally musty flavour of the species, producing the high incidence of foreign flavour noted.

Table 7. Percentage of samples with definite or strong foreign flavour resembling various odours.

Station	Percentage of samples with flavour resembling odour:						Not Classed
	1*	2	3	4	5	6	
A. of total samples presented							
34.7	0.0	0.9	3.5	0.0	1.8	0.0	1.8
22.3	31.8	0.0	18.2	0.0	24.2	0.0	0.0
15.9	6.7	0.0	13.3	0.0	13.3	3.3	10.0
10.1	22.2	0.9	16.7	0.0	16.7	0.0	0.0
B. of all samples with definite or strong foreign flavour							
34.7	0.0	11.1	44.4	0.0	22.2	0.0	22.2
22.3	42.9	0.0	24.5	0.0	32.7	0.0	0.0
15.9	14.3	0.0	28.6	0.0	28.6	7.1	21.4
10.1	39.3	1.6	29.5	0.0	29.5	0.0	0.0
22.3)	37.9	0.8	27.4	0.0	30.6	0.8	2.4
15.9)							
10.1)							

*See foot-note **, Table 6.

CONCLUSIONS

1. The geometric mean threshold odour of water from Station 22.3 in the St. Lawrence River immediately downstream of Cornwall was at least twice as large as those determined for water from Stations 15.9, 10.1 and 3.0 further downriver.
2. The total incidence of foreign flavour, and of foreign flavour classed as definite or strong, was highest in fish samples from Station 22.3 and decreased progressively in the 19 miles downstream.
3. The occurrence of foreign flavour, and definite or strong foreign flavour, in samples of each species and of all species collectively was significantly higher at Station 22.3, 15.9 and 10.1 than was found in samples from Station 34.7 upstream of Cornwall. Foreign flavour classed as barely perceptible was not significantly more frequent at Station 22.3 than it was at the upstream location, but greater incidences in this category did occur at Station 15.9, 10.1 and 3.0.
4. Definite or strong foreign flavour was found in 7.6 per cent of all fish samples from the stations upstream of Cornwall and in 55.8 per cent of all samples from downstream locations.
5. On the basis of at least two out of three samples of each fish rated as having definite or strong foreign flavour, the percentage of individuals which could be considered tainted was calculated to be 2 per cent at Station 34.7, 81 per cent at Station 22.3, and 50, 44 and 0 per cent at Stations 15.9, 10.1 and 3.0 respectively. The

- percentage of tainted individuals from Stations 22.3, 15.9 and 10.1 collectively was 57, and for each species ranged from 32 per cent of the pike to 92 per cent of the carp.
6. Incidence of foreign flavour classed as definite or strong did not differ significantly among the various species collected upstream of Cornwall. In general this was true also for a given location downstream but suckers showed a higher frequency than the pike at Station 22.3, and carp from Station 10.1 yielded an incidence greater than all other species from that location.
 7. The data for Stations 22.3 and 10.1 collectively indicate that the order of decreasing frequency of definite or strong foreign flavour among the species tested was: carp, suckers, perch, bullheads and pike. High frequencies of the taint were not limited to bottom-feeding species and all bottom-feeders were not affected equally.
 8. Of six odours presented for comparison with foreign flavour in fish samples, including wastes from Cornwall industries and water exposed to the natural odour of aquatic plants, panelists selected stove oil from Domtar, total waste from Domtar and digester relief gas condensate from Domtar in approximately equal frequencies which, together, accounted for 96 per cent of the samples with definite or strong foreign flavour compared from Stations 22.3, 15.9 and 10.1.

9. The results of this study indicate that the water of the St. Lawrence River in the vicinity of Cornwall imparted a taint to the flesh of a large percentage of fish of several species and that, while the frequency and intensity of the taint declined downstream, considerable impairment of flavour occurred for at least 13 miles. The taint was deemed to resemble most closely wastes from the Domtar Pulp and Paper Company plant at Cornwall.

REFERENCES CITED

American Public Health Association, American Water Works Association and Water Pollution Control Federation. 1960. Standard methods for the examination of water and wastewater, including bottom sediments and sludges. 11th ed. American Public Health Association, Inc., New York. 626 pp.

Baldwin, Ruth, Dorothy H. Strong and J. H. Torrie. 1961. Flavor and aroma of fish taken from four fresh-water sources. Trans. Amer. Fish. Soc. 90 (2): 175-180.

----- 1962. A study of the influence of selected preparation procedures on flavor and aroma of fish. Food Technology XVI (7): 115-118.

Cochran, W. G., and Gertrude M. Cox. 1962. Experimental designs. 2nd ed. John Wiley and Sons, Inc., New York. 611 pp.

Snedecor, G. W. 1956. Statistical methods. 5th ed. Iowa State College Press, Ames, Iowa. 534 pp.

Prepared by:

Supervised by:

Yvonne H. Swabey
.....
Yvonne H. Swabey, B.A. (Hon.)

.....
John H. Neil, M.A., C.P.H.



96936000009450