By Paul B. Liao*

Pollution potential of salmonid fish hatcheries

The potential problem of pollutants discharged from a salmonid fish hatchery has long been overlooked. There is almost no literature on the subject. It has been argued that effluents discharged from a salmonid fish hatchery cause no water pollution problem because of their nature. A recent survey and field test reveals there are water pollution problems associated with salmonid hatchery operations and that some corrections have been made.

This paper discusses the work performed by the author, including literature, and questionnaire surveys and field tests. The study began in February 1969, and ended in February 1970.

Fish hatchery process. A typical salmonid fish hatchery includes propagation facilities such as holding ponds for the adult fish to spawn, incubators, rearing tanks and raceways as required to rear young to release size. The major operation requirements are water supply, fish loading facilities, feeding equipment and cleaning equipment.

It is most important in satisfactory hatchery operation to furnish a suitable water supply. Hatcheries probably utilize more water per pound of product than any manufacturing process. Water requirements depend mainly upon fish size and water temperature. In general, water required is directly proportional to water temperature and inversely proportional to the fish size. It can be seen from Figure I with water at 50 °F and an average fish size of 40 grams per fish, the water use rate is I gpm per 25 lb of fish (i.e., 8,640 gpd per 150 lb of fish, which is approximately 100 times per capita water consumption rate). The required pond volume (fish loading density) is proportional to fish size and inversely proportional to water temperature, according to some authors. Figure 2 represents the relationship between loading density and fish size at various water temperatures as suggested by various authors.

Hatchery fish feeding is a science which is continually developing. Normally young fry in the rearing tanks are fed a dry mash which floats. The older fingerlings and adults in the raceways are fed pelleted foods of various

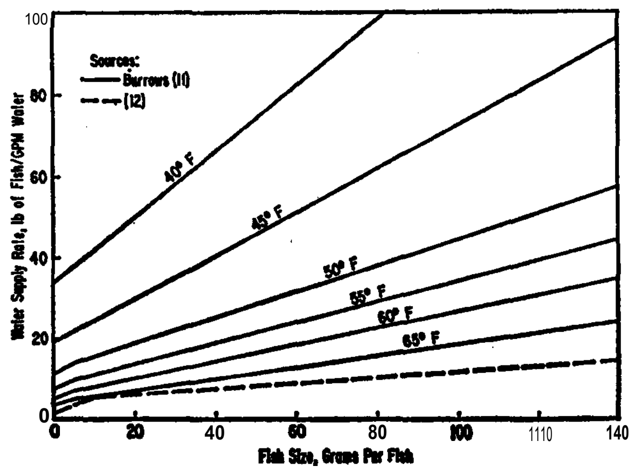

Figure I: Water supply rate versus fish size at various water temperatures

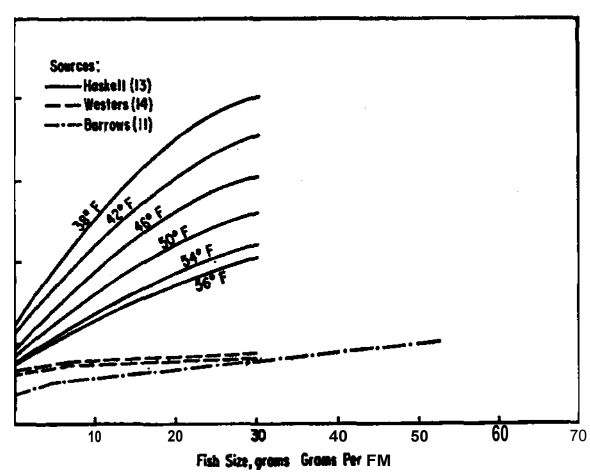

Figure 2: Loading density versus fish size at various water temper-attires

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gradations which sink. The most common of the pelleted foods in Western hatcheries is the Oregon moist pellet. On the average, the food contains <35 percent moisture, >35 percent protein, >5 percent fat, <4 percent fiber. Young fry are usually fed 8 times each day. Older fingerlings are fed two or three times each day. The amount of food is based on water temperature and the weight of fish in the pond, and is less than 10 percent of fish weight per day.

The rearing ponds are cleaned at intervals varying from daily to monthly. When the ponds are being cleaned the effluent may consist of fish fecal wastes, unconsumed food, weeds, algae, chemicals and drugs. The quantities of these components cannot be precisely determined, but are such that they constitute the major pollution problem.

Problems. Pollutional problems reported to be associated with fish hatchery operations include nutritional enrichment, algae and weed growth, taste and odor, settleable solids, pathogenic bacteria and parasites, organic matter, chemicals and drugs. Some pollution examples follow:

I. The first example is that of the Bureau of Sport Fisheries and Wildlife's (BSF&W) Jordan River (Michigan) National Fish Hatchery which began operation in 1964. Since that time there have been numerous articles in local newspapers protesting the alleged pollution. During the spring of 1966 the BSF&W conducted a study to determine the effects of the hatchery on the chemical quality of the river. This study, while showing high levels of nutrients in the river, indicated that the hatchery's contribution to the total load was very small. In the fall of 1968 the Federal Water Pollution Control Administration (FWPCA)** was requested to conduct an evaluation of possible pollution of the Jordan River by the hatchery. The results indicated that (a) the Jordan River National Fish Hatchery contributes significant amounts of fish-fecal materials and unconsumed fish food to the Jordan River, (b) this material is deposited on the bottom and along the bank of the river and supports pollution-tolerant benthic organisms and (c) these deposits are in violation of the intrastate water quality standards of the State of Michigan.[1]

2'. The second example comes from the California Department of Fish and Game, San Joaquin Hatchery in 1965. A preliminary investigation revealed that below the discharge, gravel was completely covered with sludge originating at the hatchery. These deposits, measured at random points, were up to 12 in. deep averaging about 3 in. overall, and that tubifex worms (blood worms) were so numerous that they created a red mottled pattern all over the bottom. One handful from such a spot produced several hundred worms. The actual rate of deposition of solids was unknown but a piece of wire gauze screening 15 in. x 10 in. collected 29.3 g of solids in three minutes when held in the outfall during the cleaning of the ponds. Streamers of an unidentified form of algae blanketed a large area as a result of the excessive nutrients. Dead fish were also found in the area year-around. It is obvious from this preliminary investigation that there is a pollution problem at the hatchery.[2]

3. A third and critical example of an alleged pollution problem is demonstrated by a civil action brought against the Colorado Game, Fish and Park Division's Rifle Falls Trout Hatchery. This action resulted in a court order, upheld by the Colorado Supreme Court, requiring the hatchery to pay damages and also to abate pollution to the stream. Fish have been removed from the hatchery until pollution abatement facilities are installed and in operation.[8] A trickling filter type pollution control unit has been proposed for this trout hatchery.[4]

The above three examples suggest that pollution problems associated with salmonid fish hatchery operations do exist. There are other examples to which the readers may refer.[illegible] It is understood that pollution control facilities have been provided at the first two hatcheries.

Literature review. As part of this study, a detailed review was made of various standard literature sources to determine if there have been any papers published relating to pollution caused by fish hatcheries. This literature search included a review of the cumulative index of many publications and when no satisfactory data were obtained, a detailed study of the abstract sources for a broad range of publications was made. By groups, the abstracts investigated included:

Sports fishery abstracts. All abstracts from 1955 to date were reviewed with no positive results.

Wafer pollution abstracts. All abstracts of the various publications relating to water pollution were reviewed from 1961 to date with no positive results.

Public health engineering abstracts. These abstracts from 1960 to date were reviewed in detail with no positive results.

In summary, the standard literature sources of all North American publications and many European publications were covered. No articles of any significance have been found concerning hatcheries as pollutional sources. However, the author did obtain several special reports[illegible] from various sources relating to fish hatchery pollution studies.

Questionnaire survey. A general information request relating to individual problems was made of all federal agencies operating hatcheries, all state agencies with a direct interest in hatchery propagation and all Canadian federal and provincial fisheries agencies. Virtually all (63 agencies) replied (Table I). Thirteen indicated that they had pollution problems, nine have made studies,

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Table I. Result of Questionnaire Survey

	Salmon Hatcheries No./Annual Production in Pounds	Trout Hatcheries No./Annual Production in Pounds	Have Had Problems:	Have Made Studies?	Have Had Special Construction:	Feed is a Potential Problem
Bureau of Sport Fisheries & Wildlife						
Pacific Region	9/1,110,000	9/946,000	No	No	No	No
North Central Region	0	12/501,000	Yes	No	No	Yes
Southeast Region	0	10/	No	No	No	No
Northeast Region	1/21,500	9/828,000	Yes	Yes	Yes	Yes
Alabama---Department of Conservation	No Salmonid Hatcheries					
Alaska-Department of Fish & Game	4/15,000	6/2,000	No	No	Yes	No
Arizona-Game & Fish Department	0	3/250,000	No	No	No	No
California-Department of Fish & Game	5/147,000	14/2,390,000	Yes	No	Yes	—
Colorado-Div. of Game, Fish & Parks	6/Fry	20/1,790,000	Yes	Yes	No	Yes
Connecticut-Board of Fisheries & Game	0	3/110,000		No	No	Yes
Delaware-Board of Game & Fish Comm.	No Salmonid Hatcheries					
Florida-Game & Fresh Water Fish Comm.	No Salmonid Hatcheries					
Georgia-State Game & Fish Commission	0	2/100,000	No	No	No	No
Hawaii-Division of Fish & Game	No Salmonid Hatcheries					
Idaho-Fish & Game Department	2/60,000	15/1,200,000	No	No	No	No
Illinois-Department of Conservation	No Salmonid Hatcheries					
Indiana-Department of Natural Resources	0	1/25,000	No	No	No	No
Iowa—State Conservation Commission	0	3/125,000	Yes	Yes	Yes	Yes
Kansas-Forestry, Fish & Game Comm.	No Salmonid Hatcheries					
Kentucky-Dept. of Fish & Wildlife Res.	No Salmonid Hatcheries					
Louisiana-Wildlife & Fisheries Comm.	No Salmonid Hatcheries					
Maine-Dept. of Inland Fisheries & Game	1/30,000	9/110,000**	No	No	No	No
Maryland-Dept. of Game & Inland Fish	0	3/54,000	No	—	No	No
Massachusetts—Div. of Fish & Game	I/Fingerling	4/400,000	No	—	Yes	—
Michigan-Dept. of Natural Resources	-/107,560	6/230,000**				
Mississippi-Game & Fish Commission	No Salmonid Hatcheries					
Missouri-Dept. of Conservation	0	5/740,000	No	Yes	No	Yes
Montana-Fish & Game Department	0	8/320,000[5]*	No	No	—	No
Nebraska-Game & Parks Commission	0	2/140,000	No	No	No	No
Nevada-Fish & Game Commission	0	4/250,000	No	No	No	No
New Hampshire-Fish & Game Dept.	2/5,766	6/194,000	No	No	No	No
New Mexico-Dept. of Game & Fish	0	6/400,000	No	No	No	No
New York-Conservation Department	0	14/600,000	Yes	No	No	Yes
North Carolina-Wildlife Resources Comm.	0	4/147,400	No	No	No	No
North Dakota-State Game & Fish Dept.	No Salmonid Hatcheries					
Ohio-Division of Wildlife	2/8000	1/7000	No	No	No	No
Oklahoma-Dept. of Wildlife Conserv.	No Salmonid Hatcheries					
Oregon-Fish Commission	15/1,200,000	0	No	Yes	No	No
Oregon-State Game Commission	0	15/1,300,000**	Yes	No	No	Yes
Rhode Island-Dept. of Natural Resources	0	2/45,000	No	No	No	Yes
South Carolina-Wildlife Resources Dept.	No Salmonid Hatcheries					
Tennessee-Game & Fish Commission	0	3/175,000	No	No	No	No
Texas-Parks & Wildlife Department	No Salmonid Hatcheries					
Utah-Fish & Game Division	0	11/950,000		Yes	No	—
Vermont-Fish & Game Department	1/8500	5/270,000	Yes	No	No	Yes
Washington-Department of Fisheries	25/2,225,000	0	No	No	No	—
Washington-Department of Game	0	32/1,500,000	No	No	No	No
West Virginia-Dept. of Natural Resources	0	5/275,000	No	No	No	Yes
Wisconsin-Dept. of Natural Resources	0	12/395,000**	Yes	Yes	Yes	Yes
Wyoming-Game & Fish Commission	0	11/383,240	No	No	No	No
Pennsylvania Fish Commission	1/12,742	7/800,00	Yes	No	Yes	Yes
New Jersey, Bureau of Fisheries Management	0	1/200,000	Yes	No	No	Yes
South Dakota Dept. of Game, Fish & Parks	0	1/60,000	Yes	Yes	Yes	Yes
Virginia Commission of Game & Inland Fisheries	0	3/350,000	No	No	No	Yes
Minnesota Department of Conservation	1/7200	3/82350	No	No	No	No
Dept. of Fisheries-Ottawa, Ontario, Canada						
Newfoundland Region	No Salmonid Hatcheries					
Maritimes Region	7/120,600	7/116,826	No	**No**	**No**	**No**
Central Region	No Salmonid Hatcheries (Provential Control)					
Quebec Region	No Salmonid Hatcheries (Provential Control)					
Pacific Region	No Salmonid Hatcheries					
British Columbia-Dept. of Recrea. & Cons.	0	3/50,000	No	Yes	No	Yes
Manitoba-Dept. of Mines & Natural Res.	0		No	No	No	No
Ontario-Dept. of Lands & Forests	2/11,000	16/275,000	Yes	No	No	**Yes**

**Combined Salmon Trout.

Summary

Total number of replies	63	
Total with Salmonid Hatcheries	46	
Total annual Salmonid production	24,176,684 Pounds	
Have had problem?	Yes—13	**No-30**
Have made studies?	**Yes-9**	**No-34**
Have had special construction?	Yes-8	**No-36**
Feel is a potential problem?	Yes-18	No-23

eight have provided special control units and eighteen felt that there was a potential problem of fish hatchery wastes.

Field testing. Generally, three types of pollutants are discharged from fish hatcheries. They are:

a. Fish fecal wastes and residual food.

b. Chemicals and drugs—used for disease and parasite control.

c. Pathogenic bacteria and parasites.

The second and third categories, although important to an understanding of the total effect of hatchery wastes on the receiving water, are sporadic in nature. The first group of factors, including those that contribute to the chemical and/or physical degradation of receiving water quality, is of most concern because these factors are encountered continuously throughout the year under normal hatchery operating procedures. Therefore, field testing done by the author for this study was confined to measuring the waste characteristics included in the first category. From February to June 1969, field tests were made at the Green River Salmon Hatchery and the Cowlitz Trout Hatchery in the State of Washington. Rearing units in each were selected for sampling of influent and effluent flows. Water samples were taken over a 24-hr period at 4-hr intervals. These samples were then analyzed individually to determine the following characteristics: COD, BOD, DO, pH, ammonia, nitrate, phosphate, suspended solids, dissolved solids, settleable solids, total solids and total volatile solids. With each sample the following items were recorded: fish species (size, age and weight), flow, feed (type and quantity), temperature, weather, time, and raceway size and type. The results are presented in Figures 3-5 and Tables 2-3. Further tests were made at Cowlitz Trout Hatchery from June to September, 1969.[8] The result of the test was similar to the first series. From November 1969 to February 1970, a rearing unit at Seward Park Trout Hatchery in Seattle, Washington, was selected for determining BOD removal efficiency and relationships between oxygen uptake rate, BOD production rate, fish size and feed rates. The relationships between oxygen uptake rate, BOD production rate and fish size derived from this test are indicated in Figure 6.

Discussion and conclusions. I. Pollutants—types and quantities. As indicated in Tables 2 and 3, the pollutants (excluding chemicals, pathogens and sanitary sewage) discharged from fish hatcheries can be classified into three groups: organic, nutrient and solid.

a. Organic pollutants. Due to the high water consumption of a fish hatchery (average of these tests was 34,000 gpd per 100 lb of fish), most of the BOD test values for hatchery effluent at normal operation was less than 10 mg/I. Such a concentration will probably meet many water quality standards throughout the United States. However, the average BOD production per day per 100 lb of fish is 1.34 lb which is equivalent to that produced by about ten people. The average BOD concentration of hatchery effluents during pond cleaning is several times greater than that during normal operation. In tests where the fish loading density is greater than 25 lb of fish per gpm, the average BOD concentration is in excess of 35 mg/I. This is well in excess of the strength of waste from a normal secondary sewage treatment plant and most probably is not acceptable in terms of most water quality standards. One important parameter which is closely related to BOD is the dissolved oxygen (DO) level. Most of the DO is taken up by the fish in the pond resulting in a low DO in the effluent. The DO depletion in water passing through the hatchery is mainly due to direct fish uptake and partly due to atmospheric losses and benthal oxygen demand. In this study the depletion of DO in the hatchery is based on total loss per 100 lb of fish per day. The DO depletion was found to range from 0.246 to 1.754 lb of oxygen per 100 lb of fish per day, with an average of 0.727.

b. Nutrient pollutants. The nutrient pollutants, nitrate and phosphate, are the end-products of decomposition of fish food. Test results indicate that the average hatchery effluent contains 1.68 mg/I of nitrate and 0.077 mg/I phosphate and 0.53 mg/I of ammonia. Ammonia will be oxidized to nitrite and then nitrate, and thus increase nutrient level. The hatchery effluent tested may stimulate algae growth and cause algae blooms under certain conditions of sunlight and warmth.

c. Solids pollutants. Under normal operating conditions total solids concentrations ranged from 30 to 190 mg/I with an average of 85 mg/I. On the average, 92 percent of total solids were dissolved solids and 35 percent were volatile solids. The suspended solids concentration ranged from 0 to 35 mg/I with an average of 7 mg/I, of which about 50 percent were settleable. When the ponds were being cleaned, the average total solids concentration was 174 mg/I, of which about 45 percent were dissolved and 62 percent were volatile solids. The suspended solids concentration ranged from 85 to 104 mg/I with an average of 96 mg/I. On the average, about 89 pecent were settleable. This high percentage of suspended and settleable solids indicates that most of the solids contained in the cleaning water will immediately deposit on the stream bottom below the hatchery. Field observations indicated that there were discernible differences in local bottom conditions between the water courses upstream and downsteam of the hatchery. To describe these differences as pollution effects would be unreasonable in light of the limited observation.

2. Relationship between pollutants. Production and hatchery operating procedures. There are relationships between pollutant production rates, feeding rates, fish size, loading densities and water supply rates, although the result is erratic because the ponds tested were randomly selected. As shown in Figures 3-5, it appears that DO uptake, BOD, nitrate, ammonia and phosphate production rates are proportional to the food feeding rates. The lower the feeding rate, the smaller the pollutant production rate and the lower the DO uptake rate. Also it appears that the pollutant production rates are inversely proportional to the fish size and loading densities and water supply rates. The higher the loading densities, the smaller are the pollutant production rates, and vice versa. This is probably due to the effective food uptake by the fish and the lesser available space for fish activity. As a result, less food is left uneaten and the fish activity reduction results in less fecal waste production. Further, the decrease in loading density may also reduce the

Table 2. Pollutants Production Rates at Various Conditions

Size inches	lbs. fish per gpm	lbs. fish per cuff	lbs. food per 100 lbs. fish per day	Temp., °F air/water	lbs. BOD per 100 lbs. fish per day	lbs. ammonia per 100 lbs. fish per day	lbs. nitrate per 100 lbs. fish per day	lbs. phosphate per 100 lbs. fish per day
6"	26	1.14	1.41	48/54	1.61	0.065	0.006	0.0040
1.5	1.3	0.069	2.42	48/54	1.17	0.105	0.318	0.0465
2.5	4.24	0.167	4.63	50/44	1.234	0.310	0.234	0.0143
2.5	6.13	0.393	4.60	50/44	0.881	0.332	0.160	0.0100
2	3.80	0.231	4.62	50/44	1.342	0.404	0.272	0.0114
2	1.17	0.1	4.25	55/58	1.230	0.04	0.573	0.0372
2	1.63	0.136	4.36	55/58	0.866	0.078	0.246	0.0109
2	1.27	0.136	4.36	55/58	0.966	0.032	0.690	0.0863
8	2.05	0.418	2.5	48/64	1.94	0.039	0.696	0.0146
9	1.65	0.421	2.08	48/64	1.805	0.372	0.400	0.0143
3	1.00	0.149	7.15	48/65	2.496	0.294	0.582	0.043
8	0.523	0.182	4.80	47/50	1.430	0.218	1.501	0.087
4	1.83	0.375	3.78	48/50	1.731	0.066	0.189	0.094
5	6.11	0.835	2.0	48/56	0.648	0.108	0.088	0.0131
10	4.9	0.526	1.67	48/56	0.787	0.031	0.066	0.015
Range	0.52-26.0	0.069-1.14	1.14-7.15		0.645-2.496	0.031-0.404	0.006-1.501	0.004-0.094
ave.	4.24	0.350	3.561		1.342	0.166	0.401	0.0333

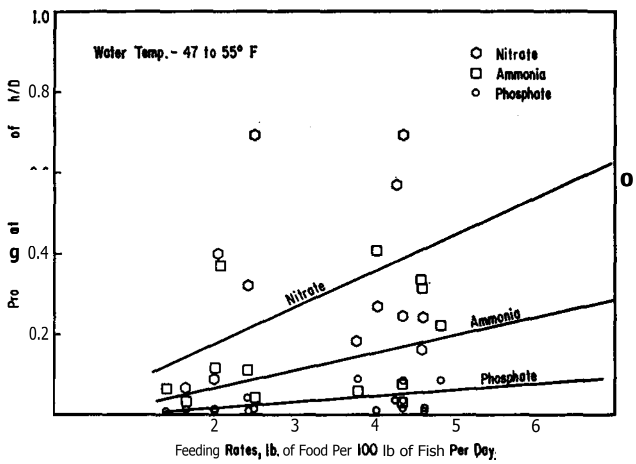

Figure 3: Nutrient production rates versus feeding rates

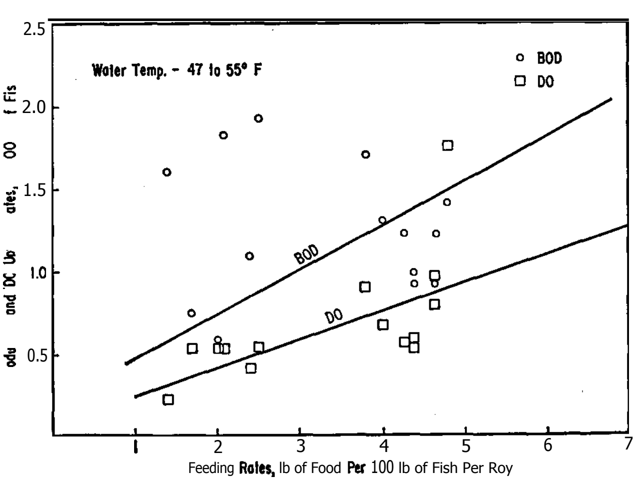

Figure 4: BOD production and DO uptake rates at various feeding levels

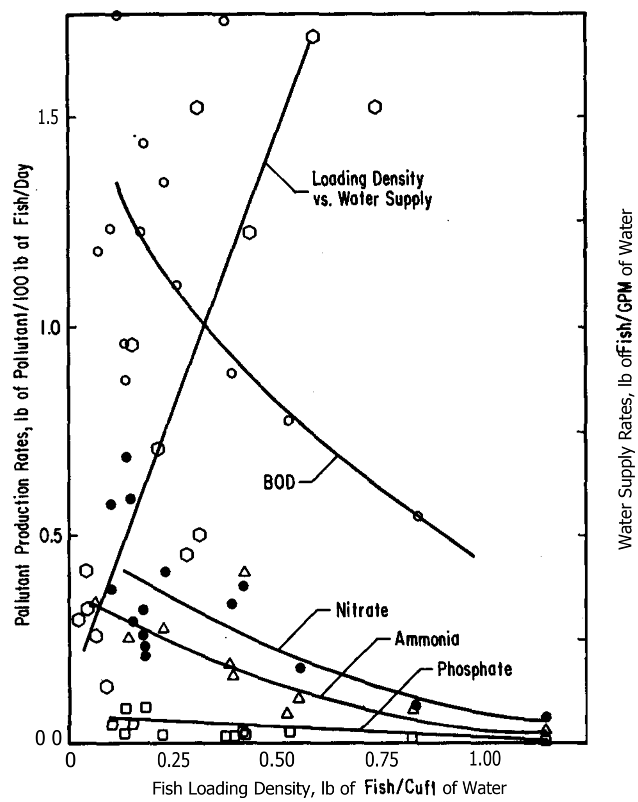

Figure 5: Relationships between pollutant production rates, water supply rates and fish loading densities

Table 3. Average increase in pollutants concentrations

Pollutants	Average Increase, ppm A	Average Increase, ppm B	Range, ppm A	Range, ppm B
BOD	5.36	33.6	0.12-36.5	18-49
Ammonia	0.532		0.00-2.55	
Nitrate	1.676		0.045-3.1	
Phosphate	0.077		0.010-0.262	
Suspended Solid	7.0	96	0.0-55	85-104
Settleable Solid	3.5	85	0.0-35	78-89
Dissolved Solid	78	78	25.0-186	70-81
Total Solids	85	174	30.0-190	166-185
Total Volatile	29	108	5.0-100	90-125

A= Normal operation
B = Ponds being cleaned
- Test not conducted

probability of food uptake by the fish resulting in an increase in residual food which finally settles to the bottom and becomes a part of the fish wastes.

The relationship between fish size and pollutant production rate is illustrated in Figure 6. As can be seen, when the fish grow the pollutant production rate decreases. This is probably due to efficient food uptake resulting in little residual food. Information in Figure 6 was derived from the Seward Park Trout Hatchery study.

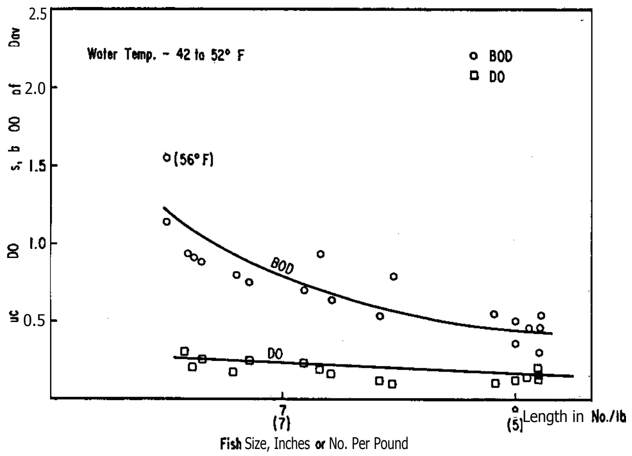

Figure 6: BOD production and DO uptake rates versus fish size

The BOD production rate, with an average of 0.75 lb per 100 lb of fish per day, is much less than the previous tests (where the average BOD production rate was 1.34). The corresponding average feeding rates were 1.3 and 4.2 lb per 100 lb of fish per day, respectively. It is obvious that proper feeding will greatly reduce the rate of pollutant production.

3. Pollution potential. In some of the initial contacts with various agencies, mild objections to the phrase "pollutional effect' as related to hatcheries were raised. However, pollution has existed, and survey and field test results confirm this, particularly when pond cleaning is taking place. At some locations, due to the high water consumption rates, most of the stream water is diverted to the hatcheries. The diverted water, once returned to the stream, carries various pollutants, and under certain conditions the DO content in the returned water is low (<5 mg/I). It is possible that the mixture of the hatchery effluent and undiverted water will have a DO content less than 6 mg/I. A DO concentration greater than or equal to 6 mg/I has been set as the receiving water quality standard by many states. Further, due to the fairly high nutrient contents, algae growth in the receiving water may be stimulated, and under certain circumstances algae blooms will occur. The depletion of DO and the growth of algae are in violation of most receiving water quality standards. When pond cleaning is taking place the strength of the pollutants contained in the hatchery effluent is fairly high. It was observed that most of the solids contained in the cleaning water settle out in one hour in an Imhoff cone. It could be expected that these solids will blanket the stream bed downstream of the hatchery if no control facility is provided. Further, it is well understood that the pollution potential of the hatchery cleaning water is comparable to domestic sewage when diluted with infiltration water.

To illustrate the potential pollution problem of fish hatchery wastes, the responding agencies reported a total annual salmonid production in excess of 24 million pounds. Adding to this hatcheries now under construction or planned for the near future, plus private facilities, an annual maximum loading of 36 mil lb of salmonids does not seem an unreasonable estimate. The day-to-day production of BOD will be 1.3 lb per 100 lb of fish per day, indicating that the pollutional effect of all the hatcheries in North America would be roughly equivalent to a population of 2.4 mil depositing untreated sewage in the rivers. This illustration is vastly oversimplified, but the author feels that it cannot be ignored.

Recommendations. The problems of pollutants discharged from salmonid fish hatcheries and some relationships between pollutant production and hatchery operating procedures have been discussed. The corrective measures must be taken for effective control. In general, water pollution from salmonid hatcheries can be controlled through in-hatchery improvements and effluent treatment, such as:

I. Hatchery operating improvements should include proper fish loading techniques, proper feeding procedures and water supply adjustments. According to Burrows," Haskell[13] and Westers," fish loading and water supply should be adjusted according to the water temperature and fish size. The water temperature for a hatchery in a particular season remains fairly constant. Therefore, fish loading and water supply may be considered as a function of fish size only. The optimum fish loading and water supply can be obtained. During the period of this study, the fish loading rates at the hatcheries tested were irregular; in most cases the loading rates were several times less than that proposed by these authors. Economically they increase unnecessary capital and operating costs of the hatchery. The author has observed that if the hatchery is operated at the levels proposed by Burrows, Haskell and Westers, the DO in the raceway effluent will be equal to or greater than 5 mg/I. The limiting value of DO for salmonids has been reported to be 2-3 mg/I[0] although some believe that oxygen levels below 6 mg/I result in a reduction in activity and ultimately a reduction in growth rate." The increase in fish loading not only reduces the capital and operating costs for the hatchery, but when water supply rate is adjusted to the optimum level, the required cost of the pollution control facilities is accordingly minimized. It is recommended that the fish loading and the water supply rates proposed by these authors, as shown in Figures 1-2, be adopted for salmonid hatchery operations.

Food feeding as found in this study is a major operating factor related to the pollutant production. Proper feeding means that the time and amount of food fed must be properly determined so that most food will be eaten, resulting in little or no food residual. This practice is an economical one since improper feeding does not improve fish growth, and results in higher operating costs as well as higher pollutant production rates. Scheduling is an important factor as it was observed that when the fish were not really hungry, they did not chase food. As a result, most foods released in the water settled out and finally became pollutants. The amount and time of feeding vary with water temperature, fish species and size, and type of food. For each hatchery these factors can be experimentally determined. Therefore, it is suggested that both time and amount of feeding be optimized for each hatchery.

2. Effluent treatment means that hatchery effluent must be effectively treated before discharge to the receiving water. The water consumption rate of fish is very high and the amount varies with operating conditions. Furthermore, hatchery operating procedure is such that if pollution control facilities are provided, they should be able to withstand both quantitative and qualitative shocks. For a hatchery where land is available, a combination of aeration and detention provides effective control. Aeration not only raises dissolved oxygen content of the hatchery effluent to near saturation, but enhances the biological decomposition of organic compounds. **A** detention pond following short term aeration will improve the efficiency and make the whole system able to sustain quantitative and qualitative shocks. For the hatcheries where land availability is restricted, proper pollution control facilities with minimum land requirement must be provided.

Summary. A recent survey and field tests reveal there are water pollution problems associated with salmonid hatchery operations. The problems of pollutants discharged from salmonid fish hatcheries and some relationships between pollutant production and hatchery operating procedures have been discussed. Possible corrective measures have also been discussed. Several treatment methods for salmonid hatchery effluent control were studied. It is suggested that concerned governmental agencies sponsor large scale investigations to determine type and quantity of pollutants discharged from various fish hatcheries. These programs should determine the effects of hatchery effluent on receiving waters and study various existing pollution control methods in detail.

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