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**Urban Aquaculture
of the Rainbow Trout
(*Salmo Gairdneri*)**

By Dr. Albert José Jones

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16. Abstract

The raising of the rainbow trout (Salmo gairdneri) in a closed recycling water system in an urban environment is described. Germ-free fingerling trout were raised on a controlled diet over a period of nine (9) months in specially constructed, refrigerated aquaria maintained at 10°C and 15°C. The results show that this trout adapts well to the environment provided for it and increases in weight and length comparable to or at a more accelerated rate than those raised by conventional fish farming methods. Rainbow trout raised at 10°C have a somewhat slower rate of growth than those raised at 15°C. Oxygen concentrations, temperature, and bacterial counts were constantly monitored. This process, with slight modifications, could be used to launch a commercial venture in the urban aquaculture of the rainbow trout.

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URBAN AQUACULTURE OF THE RAINBOW TROUT (SALMO GAIRDNERI)

Phase I

by

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FINAL REPORT

Project No. A-007-DC

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INTRODUCTION

All types of fish farming are properly described as aquaculture. Records of civilization indicate that humans have raised fish for food since antiquity. Practically all of the rainbow trout now cultivated on European fish farms are from domesticated brood stock, bred entirely under artificial conditions and dependent on human help in order to survive.

The rainbow trout (Salmo gairdneri) are members of the salmon family. Wild stocks of this fish were originally confined to rivers and lakes in the western half of North America. There are two main varieties of rainbow trout, a sea-going form known as the steelhead, which occurs in most of the rivers draining into the Pacific Ocean, and a form found exclusively in freshwater. Their average life-span averages from 4-5 years.

Because of their succulent taste man has been long engaged in farming the rainbow trout; and he is constantly seeking better, more efficient and more profitable means to realize this end. One of the major obstacles in trout farming is finding and acquiring a satisfactory site for the fish farm. This site must have an adequate supply of clean, cold water with the proper chemical quality. A closed system such as the one utilized in this research would partially eliminate these problems. Proper water chemistry requires that temperature never rises above 15°C, the pH remains between 7.0-7.5 and the highest oxygen concentration possible for a given temperature be maintained. The experimental lethal limit for rainbow trout is the region of 25° - 27°C. A temperature range of 10 -15°C has been found to be the best for farming purposes.

Trout are predatory fish that live by both catching and eating other living organisms. Their digestive systems are designed to utilize animal protein rather than vegetable products; however, they can handle limited variety of plant material. Intensive research in the United States has determined the basic nutrient requirements of the rainbow trout. The best rainbow trout foods are those which contain the maximum amount of protein; somewhere around 40-50% is considered high grade. It has been suggested by Halver (1964) that certain minimum amino-acids are required for salmonid fish (See Table #1).

Most trout can utilize relatively small quantities of digestible carbohydrates (glucose, lactose, etc.); however, not more than 9% of digestible carbohydrates should be given trout (Sedgwick, 1973). Too much digestible carbohydrates given for any length of time will cause heavy losses to stock. A small amount of digestible fat is necessary in trout diets as well as small quantities of minerals. The daily vitamin requirement for rainbow trout has been suggested by researchers in both Europe and the United States (See Table #2).

The primary objective of this research is to determine the feasibility of raising the rainbow trout (Salmo gairdneri) to a marketable size in an urban environment in closed temperature - controlled aquaria and still obtain comparable if not better growth rates as achieved through traditional fish farming methods.

EXPERIMENTAL

The organism employed in this study was the rainbow trout (Salmo gairdneri). These organisms were graciously supplied by the Department of Interior Fish Station in Warren, Pennsylvania from their germ-free stock. Three hundred rainbow trout were picked up from the Kinzua Dam Hatchery in Warren, Pennsylvania. These fingerlings were packed in 100C water in double plastic bags. These bags were filled with pure oxygen, tied and placed in three separate plastic trash cans. for support. Each bag containing one hundred fingerlings was covered with cracked ice to prevent a lethal rise in temperature during the ten-hour drive.

Four temperature-controlled aquaria, overall dimensions of 182 X 66 X 134cm, were specially constructed by and purchased from Marineland of Van Nuys, California. These environmentally controlled systems were selected for the following mechanical advantages. (Fig. 1)

1. Prefilter

A triple-density bonded polyester pad traps particulate debris.

2. Biological Filter

A large bed of crushed, fossilized oyster shell (calcium carbonate) supports aerobic bacteria. The bacteria consume organic material (fecal matter, urine, ammonia, etc.) and oxidize it to carbon dioxide and harmless nitrates. The oyster shell also acts as a buffer and maintains pH at a safe level.

3. Air Pump

Circulation is maintained by high volume air lifts which are designed to provide maximum exchange of toxic gases (ammonia, carbon dioxide, etc.)

4. Protein Skimmer

Cloudy water as an indicator of inadequate ability to support life - most frequently occurs when massive additions of organisms are made to the aquarium. Filtration during this period can be over-taxed. In order to avoid water quality degradation - proteins are trapped by concentration at a surface layer interface in a confined area, and are easily removed.

5. Activated Carbon

Marineland activated carbon is the final step in the removal of dissolved low molecular weight organics and unsightly color.

ADDITIONAL POSITIVE FEATURES

1. Heavy duty casters ... portable-just plug in to 115V 20 amp outlet.
2. Thermopane tempered glass walls for safety and viewing from all directions ... won't scratch or sweat.
3. Fiberglass aquarium base is leak proof, and insulated to eliminate sweating and reduce operating costs.
4. Heavy-duty refrigeration unit is thermostatically controlled and hermetically sealed.
5. Bottom panels - heavy-duty plastic and easily removed.
6. Easy to drain.
No metal to contaminate water.

At first the trout were fed according to the traditional rainbow trout feeding tables (See Tables 3 & 4). It was discovered that utilizing these tables for the conditions under which these trout were raised produced an overfeeding condition; consequently feeding had to be adjusted to number and size of fish and their ability to consume all food that was introduced into the tank.

Prior to the introduction of the trout, length and weight determinations were made, recorded, and graphed (See Figure 2 and 3). Each week a predetermined number of fish were randomly netted and weighed.

The fish were fed on a five day a week schedule with extra heavy feedings on Fridays and Mondays. No supplemental food was given to the specimen, only Purina Trout Chow.

Oxygen determinations were conducted every other day or at any period when the water became discolored from the dusty residue of the food. O₂ remained at a very high level throughout the experiment with an average amount 8.5. Concentrations of oxygen rose during the non-feeding periods.

Water quality was additionally checked from total counts of bacteria in each tank. Nutrient agar placed in Petri dishes was used as the media for growth. Plates were incubated at 37°C for twenty-four hours. Total counts were determined under a colony counter. Comparisons were made to determine if any unusual rise in total counts were observed. Whenever any drastic rise in counts were encountered, the fish were simply shifted to a clean tank which was always kept in reserve.

SPECIAL PROBLEMS

Water turbidity created an almost unsolvable problem. The dusty residue from the fish food would cloud the water to the point that a protein foam would cover the surface. This was partially solved by sifting the food prior to its introduction into the tank.

Food Clogging Bottom Filter

Food clogging the bottom filter was the main problem. The pellets were so small that they would be sucked through the slits in the bottom filter, clog the filter and produce cloudy water. The situation was attacked from several angles. Filters were turned off during feedings and a plastic pan was placed on the bottom of the aquaria to catch the food that was introduced to the tank and fell to the bottom. It was impossible for the fish to catch all of the food before it reached the bottom of the aquarium. The enthusiastic feeding of the fish scattered the falling food beyond the confines of the bottom pan; consequently, this problem was never fully solved.

Power Failures

Overloaded circuits, brown-outs, and power failures caused a 50% loss in stock. The electrical system was rewired to accommodate the four aquaria on separate lines.

TABLE 1

Minimum Amino-Acid Requirement for Salmonid Fish (Halver, 1964).

Arginine	2.5% of diet
Ristidine	0.7%
Lysine	2.1%
Methionine	0.5%
Cystine	1.0%
Tryptophan	0.2%
Threonine	0.8%
Valine	1.5%
Leucine	1.0%
Isoleucine	1.5%

TABLE 2

Daily Vitamin Requirement for Trout

The following are regarded as essential minimum quantities per kg of the live body weight of the fish.

Thiamine (B ₁):	0.150-0.20 mg
Riboflavin (B ₂)	0.50 -1.0 mg
Pyridoxine (B ₆):	0.25 -0.50 mg
Biotin (H):	0.04- 0.08 mg
Nicotinic acid:	4.0 – 7.0 mg
Pantothenic acid:	1.0 – 2.0 mg
Folic acid:	0.10-0.15 mg
Inositol:	18-20 mg
Choline:	50-60 mg
Cyanocobalamin (B ₁₂):	0.0002 - 0.0003 mg

It is now known that trout require Vitamin C. They may also require the fat soluble vitamins (A,D,E, and K).

Vitamin A	8,000-10,000	IU per kg of feed
Vitamin D	1,000	IU per kg of feed
Vitamin E	125	IU per kg of feed
Vitamin K ₃	15-20 mg	IU per kg of feed
Vitamin C	450-500 mg	IU per kg of feed

TABLE 3

PURINA TROUT CHOW

FISH FEED (GROWER)

SIZE 3

Min. Crude Protein	40.0%
Min. Crude Fat	9.0%
Max. Crude Fiber	5.0%
Calcium, actual	1.3%
Phosphorus, actual	1.0%
Salt, actual	1.0%
Max. Ash	10.0%
Max. Added Minerals	1.5%
Min. I.U. Vitamin A	5500/kg

INGREDIENTS

Fish, meal, soybean meal, wheat middlings, ground yellow corn, diced whey, soybean oil, dried yeast, dehydrated alfalfa meal, corn gluten meal, calcium carbonate, salt, ethoxyquin (a preservative), vitamin A supplement, D activated animal sterol (source of vitamin D-3), menadione sodium bisulfite (source of vitamin K activity), vitamin B-12 supplement, ascorbic acid, biotin, choline chloride, folic acide, pyridoxine hydrochloride, thiamin, niacin, calcium pantothenate, riboflavin supplement, copper sulfate, iodate, cobalt carbonate, zinc sulfate.

TABLE 4

FEEDING CHART FOR TROUT

The amount of Trout Chow Fish Feed to feed is governed by the water temperature, and the size and total weight of the fish to be fed.

The body of the chart represents grams or kilograms of food to feed per 45 kilograms of fish per day on a seven day basis and is to be used as a guide. Minor adjustments may have to be made to suit individual water supplies.

WATER TEMP °C	5	6	7	8	9	10	11	12	13	14	Fish Size in Fish/kg	Trout Chow Size
5 -7.5	945g	1.0kg	1.1kg	1.3kg	1.4kg	1.5kg	1.6kg	1.8kg	1.9kg	2.1kg	660-200	#3
7.5-10	720g	810g	855g	945g	1.0kg	1.1kg	1.2kg	1.3kg	1.4kg	1.6kg	200-85	#3
10-12.5	535g	585g	630g	720g	765g	855g	900g	990g	1.1kg	1.2kg	85-45	#4
12.5-15	450g	495g	540g	585g	630g	675g	720g	810g	855g	945g	45-25	#4

EXAMPLE:

Water Temperature = 10°C, Trout Chow size of 10-12.5 cm long.

Feed 855g of Trout Chow per 45kg of trout per day.

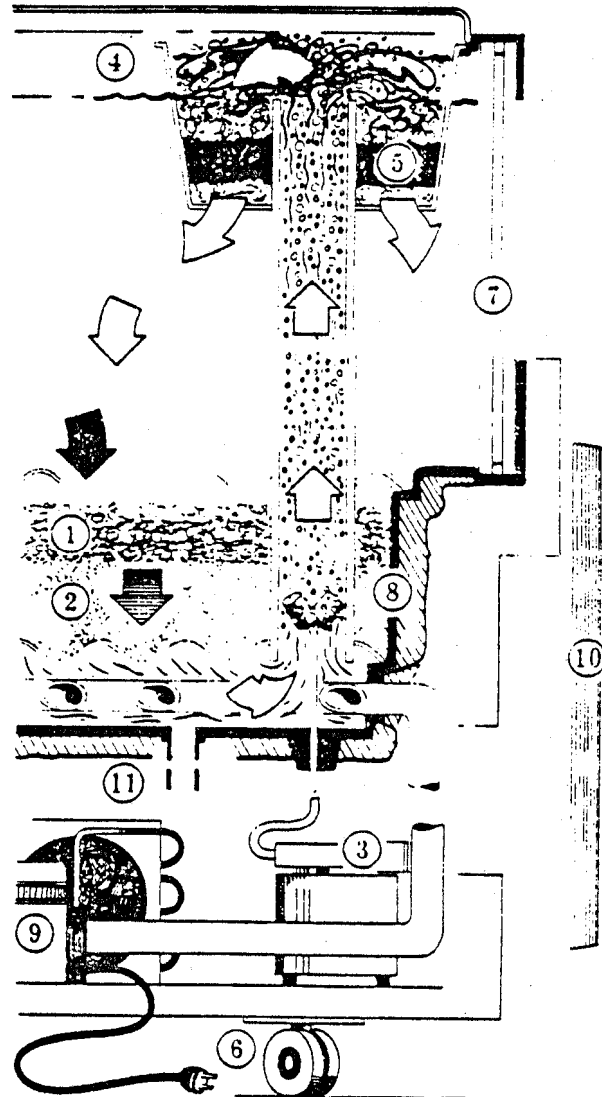
Feed in 7 days. 7×855 or 5985 or approximately 6kg per week.

If feeding on a 5-day schedule, the amount fed per day should be increased as follows:

$\frac{7 \times 855}{5} = 1197$ or 1.2 kg / 45 kg trout for 5 days. None on the other two days.

5

FIGURE 1

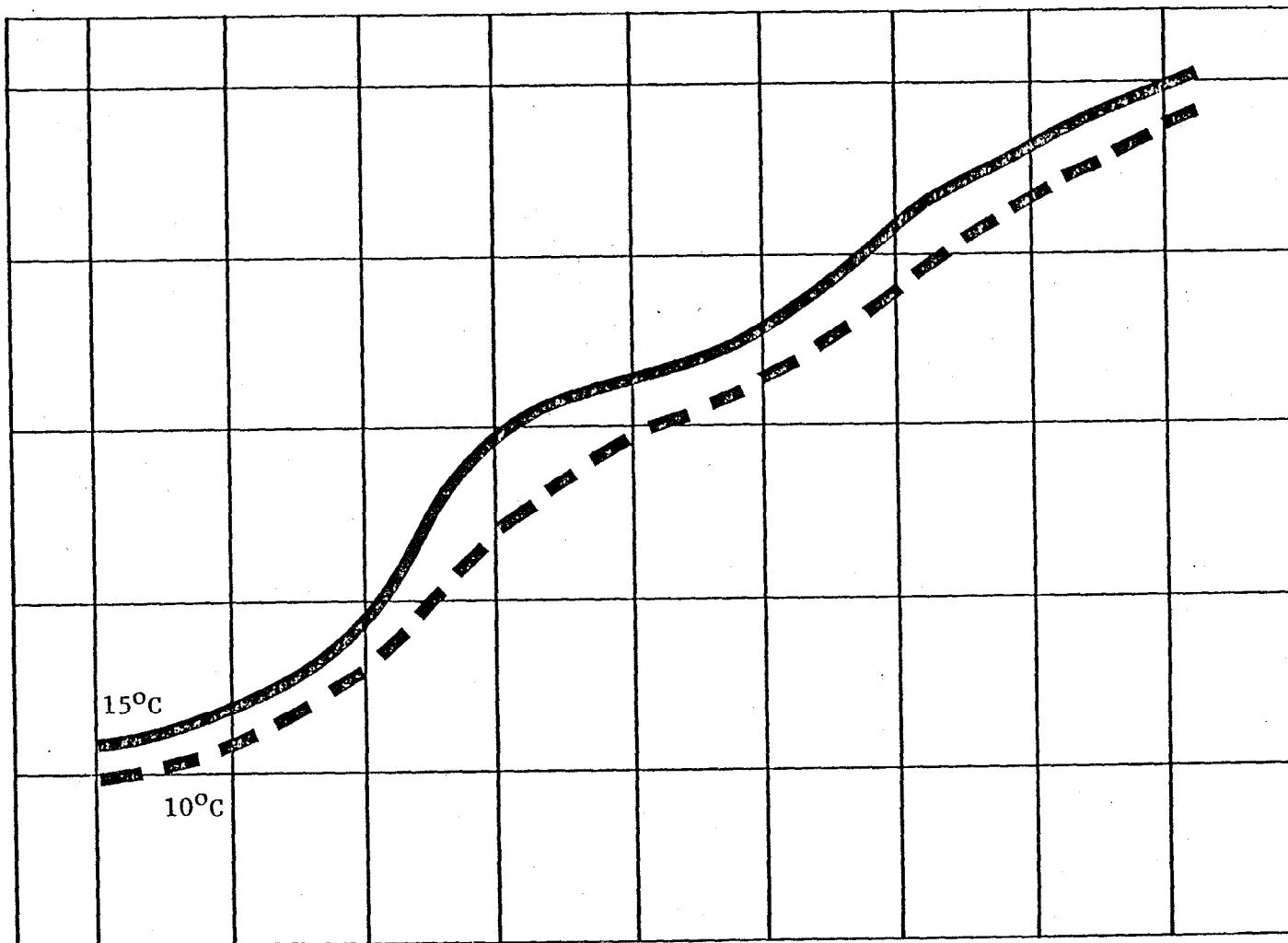


- | | |
|----------------------|------------------------------------|
| 1. Prefilter | 6. Heavy-duty casters |
| 2. Biological Filter | 7. Thermopane tempered glass walls |
| 3. Air Pump | 8. Fiberglass base |
| 4. Protein Skimmer | 9. Heavy-duty refrigeration unit |
| 5. Activated Carbon | 10. Bottom panels |
| | 11. Drain |

FIGURE 2

Length of Fish in Cm.

5
10
15
20
25

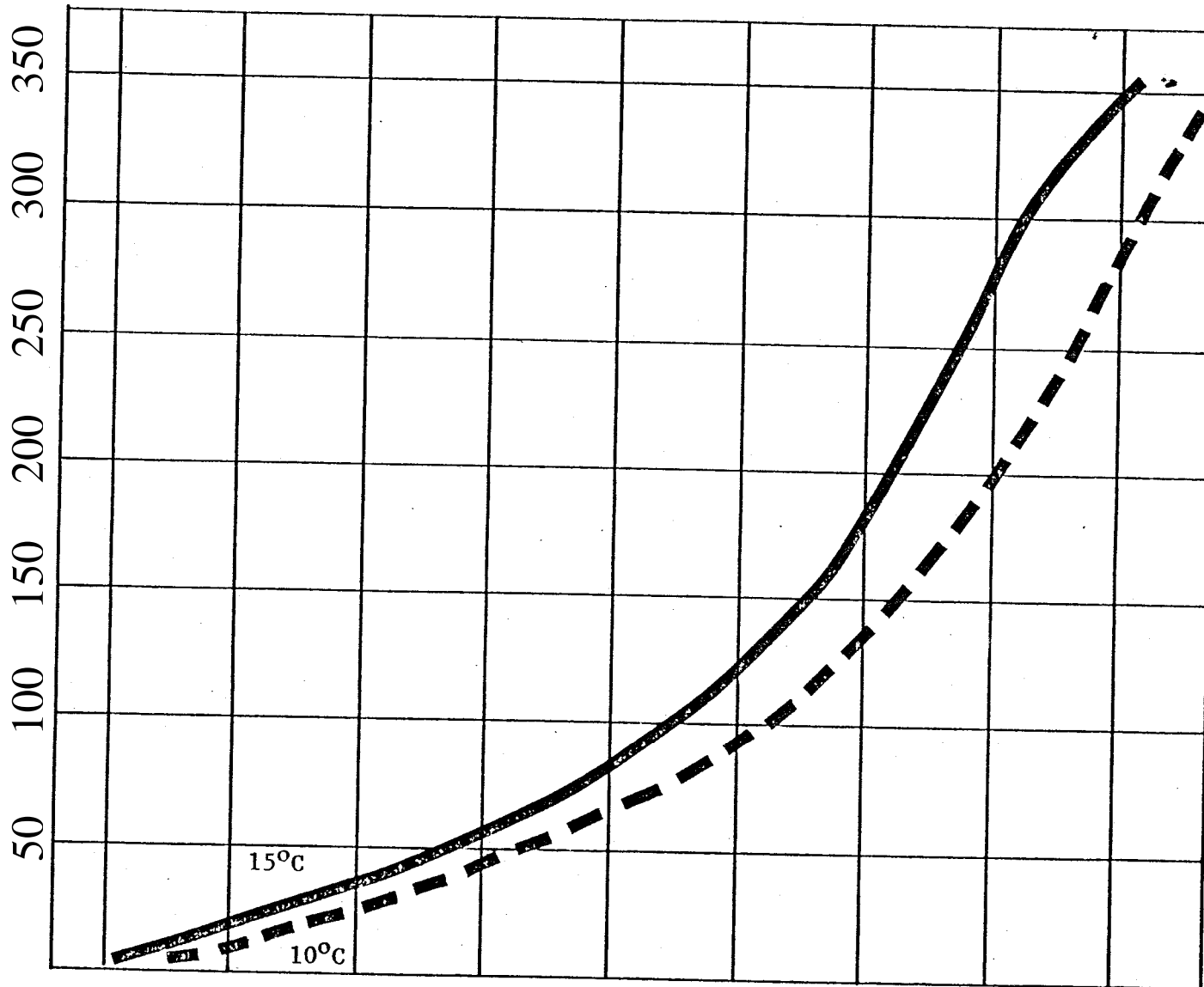


Jul Aug Sept Oct Nov Dec Jan Feb Mar
Months - 1980-81

GROWTH RATES OF SALMO GAIRDNERI

FIGURE 3

Weight of Fish in Gms.



Jul Aug Sept Oct Nov Dec Jan Feb Mar
Months of growth - 1980-81

GROWTH RATES OF SALMO GAIRDNERI

RESULTS

When the research was first begun in July 1980, no visible noticeable increase in size could be detected in the fish although they took the food heartedly. However, after two (2) months the fingerlings had increased ten-fold in weight from an average of fifty (50) grams and their length increased from seven (7) cm to twelve (12) cm. (See figures 2 and 3). Growth rates following the third month accelerated and the trout began to lose the slender appearance and develop a heavy abdominal region.

As the weight of the fish increased, they were separated into smaller groups to provide for maximum individual space and to allow maximum growth. Growth rates in 10°C water followed the same curve as those in 15°C water; however, the rates were greater in the 15 °C water (See figures 1 and 2).

The common diseases associated with trout such as furunculosis (causative organism Aeromonas salmonicida), bacterial gill disease (causative organism Mixobacterium) and fin rot (causative organism rod-shaped bacterium or the Aeromonas group) were not encountered in this research. The absence of the common diseases is attributed to use of chlorinated city water. Only one fish in 300 developed "Whirling Disease" and this case was not due to the causative organism Myxosomiasis, but to a sudden change in temperature. The fish was isolated and completely recovered.

SUMMARY

The research definitely proves that the rainbow trout (Salmo gairdneri) can be raised in the urban environment provided that their parameters for growth are maintained. The encouraging growth rates in this primer research indicate that with modifications more economical methods could be developed to make a commercial venture feasible. It was discovered that the cost factor for holding tanks could be greatly reduced if tanks were constructed of marine plywood coated with fiberglass or tar and kept in buildings or rooms of 10°C - 15°C rather than purchasing refrigerated tanks. These constructed tanks would have to be outfitted with both bottom filters and outside filters. Additional savings could be realized during colder months by simply opening windows to cool the rooms housing the tanks provided that the temperature did not reach 0°C.

Problems encountered with discolored water could possibly be eliminated by using bottom vacuum system, diatom filters and self-feeders.

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