Biological and Economic Feasibility of Commercial Arctic Charr (*Salvelinus alpinus* L.) Production Utilizing Waste Heat Aquaculture

by

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A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of Master of Natural Resources Management.

ABSTRACT

Biological and economic feasibility of commercial Arctic charr (Salvelinus alpinus L.) production utilizing waste heat aquaculture was assessed in a case study of a malt plant conversion in Winnipeg, Manitoba. Results of 3 independent growth trials demonstrated that, by using waste heat water and a modified malt vat, Arctic charr can be reared from fingerling size (25 g) to market size (200-250 g) in 165 days. Of the eight, dependent, biological operating criteria identified for the system, ammonia and nitrite concentrations were the limiting factors to fish growth. Given the limits placed on the system by water quality and water flow, the highest number of Arctic charr that could be stocked in the system was 4000. A mean specific growth rate of 1.93%/day was achieved when the maximum number of charr fingerlings were stocked in the system. A quality fish was produced by the system. Levels of contaminants present in the cultured charr such as DDT, PCB, and mercury were below human tolerance limits. Economic analysis of the production system showed a gross net return of $3,457 on an estimated capital investment of $15,771. The investment can be recovered by the company within three and a half years if no dividend is declared and the price received for cultured charr is not less than $9.75/kg. Results of a consumer survey conducted in 9 Winnipeg Safeway stores during November, 1986 indicated that cultured Arctic charr had a very good consumer acceptance. In general, it was concluded that commercial production of Arctic charr using this waste heat aquaculture system is biologically and economically feasible.

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I also wish to express my gratitude to John Kasenaar, Executive Vice-President of Dominion Malting Limited, and to the following malthouse staff: Rick Howey and Vance Kellas for their assistance in rearing the charr.

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Finally, I dedicate this work to my parents, Charles and Trudy Hathaway. Their support and encouragement made this practicum a reality.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter I

INTRODUCTION

1.1 BACKGROUND

Commercial fishing for Arctic charr (Salvelinus alpinus L.) began in Canada along the Labrador coast in the early 1940's (Kristofferson et al. 1984). In the Northwest Territories, Arctic charr were first fished commercially in 1947. Today, the Cambridge Bay commercial fishery for anadromous Arctic charr is the largest in the N.W.T., producing over 50 tonnes per year (Kristofferson et al. 1984). In the 1983/84 fiscal year, Arctic charr ranked fourth for quantity landed in the N.W.T., yet the species' average market value was $6192.00 per tonne (Table 1). The Freshwater Fish Marketing Corporation reported 43 tonnes of Arctic charr were sold to domestic and foreign markets that year (Table 2).

1.2 ARCTIC CHARR AQUACULTURE

In Europe, salmonid culture is traditionally divided into two phases: fish spend their early developmental stages in freshwater, but are transferred to sea cages where most of their growth occurs (Gjedrem and Gunnes 1978).

TABLE 1

Fish harvested in N.W.T., 1983/84 fiscal year.

Species	Quantity Landed (tonnes)	Landed Value ($)	Market Value ($)	Average Market Value ($/tonne)
Whitefish	811	571,000	1,555,000	1917
N. Pike	94	56,000	134,000	1426
Lake Trout	58	88,000	133,000	2293
Arctic charr	52	307,000	322,000	6192

Source: Freshwater Fish Marketing Corporation, 1986.

TABLE 2

Quantity of Arctic charr from N.W.T. sold in 1983/84.

DOMESTIC MARKET	QUANTITY SOLD (tonnes)
British Columbia	0.36
Alberta	20.88
Saskatchewan	0.34
Manitoba	5.54
N.W.T.	0.77
Ontario	9.22
Quebec	3.86
P.E.I.	0.03
TOTAL	41.00

FOREIGN MARKET	QUANTITY SOLD (tonnes)
United States	2.00
Europe	0.00
TOTAL	2.00

Note: Approximately 17% of quantity landed is lost through processing.

Source: Freshwater Fish Marketing Corporation, 1986.

In Norway, commercial farming of salmonids is confined to Atlantic salmon (Salmo salar L.) and rainbow trout (Salmo gairdneri Richardson), but Arctic charr was also suggested as a potential culture species (Gjedrem and Gunnes 1978, Wandsvik and Jobling 1982). Gjedrem and Gunnes (1978) reared Arctic charr under Norwegian fish farming conditions, but the fish experienced osmoregulatory problems and achieved a growth rate of only 1.45% per day. They concluded that Arctic charr was not a promising culture species in southern Norway. Wandsvik and Jobling (1982) reared Arctic charr at 13 C in freshwater and reported a significant degree of variation in the size of the fish. Their data revealed an increased Coefficient of Variation (variance divided by mean) for the whole population, which suggested that size hierarchies developed during the experiment. As a result, there was suppression of growth in the smaller members of the population (Wandsvik and Jobling 1982). They also demonstrated that growth rates of the Arctic charr increased with increasing temperature, from 0.29% per day at 2.9 C to 1.4% per day at 13.1 C. They concluded that the size variation and poor growth rates would be detrimental to future culture of Arctic charr. Subsequent research supported the hypothesis that social interactions resulting in size hierarchies were responsible for the size variation in Arctic charr (Jobling 1983, Jobling and Wandsvik 1983a). Jobling and Wandsvik (1983b) also demonstrated that Arctic charr can exist with diets of protein energy (PE): total energy (TE) ratios almost identical to dietary requirements of rainbow trout. Arctic charr, when fed diets formulated for commercial culture of rainbow trout, maintained satisfactory growth rates in the experiment (Jobling and Wandsvik 1983b). It was concluded, therefore, that special feed formu-

lations for Arctic charr were not necessary. Tabachek (1984) demonstrated, however, that not all rainbow trout or salmon diets were suitable for raising all strains of Arctic charr.

Canadian research results have, for the most part, contradicted Norwegian results concerning Arctic charr aquaculture. Uraiwan (1982) reported growth rates of 2.1% per day (7.9 - 25.1 g) for rainbow trout reared at 13 C in freshwater. Papst and Hopky (1983) observed growth rates of 2.6% per day (2.2 - 14.0 g), 2.2% per day (15.3 - 46.9 g), and 1.8% per day (46.9 - 84.7 g) for Arctic charr reared at 13.3 C. Similarly, Swift (1964) reported growth rates of over 2.0% per day for landlocked Windermere charr (Salvelinus alpinus Willughbii) in the optimum temperature range of 12 - 16 C. Canadian and British results affirm the hypothesis that Arctic charr can be reared successfully in an intensive freshwater culture system.

Papst and Hopky (1983) observed variation on body weights of Arctic charr consistent with that reported by Wandsvik and Jobling (1982). The observed variation may represent natural growth variation of the species, or reflect the effects of size hierarchy formation within the population as suggested by Wandsvik and Jobling (1982) (Papst and Hopky 1983).

1.2.1 Waste Heat Utilization

Waste heat utilization in aquaculture has become increasingly accepted because of the numerous benefits that have resulted:

1. A lengthened or year-round growing season;

2. Optimization of the aquaculture facility with resultant reduction in production costs;

3. Production of commercial species near marketing sites; and

4. Production of tropical and arctic organisms in temperate climates (Tennessee Valley Authority 1977).

Most of the American waste heat aquaculture industry is concentrated on the production of oysters, clams, lobsters and shrimp, but salmon and rainbow trout culture has increased (Table 3). Thermal effluents have also been used to produce rainbow trout in Britain, West Germany, Poland and the Soviet Union (Tennessee Valley Authority 1977).

TABLE 3

Some waste heat aquaculture projects in the U.S.A. (Tennessee Valley Authority 1977).

ORGANIZATION	LOCATION	ACTIVITY
Catfish		
Tennessee Valley Authority	Gallatin, TN	Research
Kansas Gas and Electric Co.	Colwich, KS	Research
Kansas Power and Light Co.	Hutchinson, KS	Research
Aquarium Farms, Inc.	Freemont, NE	Commercial
Kraft, Inc.	Harrisburg, PA	Research
Cultured Catfish, Inc.	Colorado City, TX	Commercial
Lobsters		
San Diego State University	San Diego, CA	Research
Boston Edison Company	Boston, MA	Feasibility
Oysters, Mussels or Clams		
Long Island Oyster Farms	Northport, NY	Commercial
University of Maine	Orono, ME	Research
University of Conneticut	Norwalk, CT	Research
Maine Dept. Marine Resources	Wiscasset, ME	Research
University of Massachusetts	Amherst, MA	Feasibility
Salmon		
Maine Salmon Farm	Wiscasset, ME	Commercial
Oregon State University	Corvallis, OR	Research
University of Washington	Seattle, WA	Research
Weyerhaeuser Company	Springfield, OR	Commercial
Boston Edison Company	Boston, MA	Feasibility
Puget Sound Power & Light	Seattle, WA	Feasibility
Alaska Dept. of Fish and Game	Juneau, AK	Feasibility
Trout		
Public Service Electric Co.	Trenton, NJ	Research
Marine Salmon Farms	Wiscasset, ME	Commercial

Waste heat technology has not, however, been as widely accepted in the Canadian aquaculture industry. In most cases, the facility producing waste heat is not located near a source of high quality water which is the main requirement for aquaculture (Papst and Hopky 1982).

By using solar rearing units as an analogue for a low-grade heat system, Papst and Hopky (1982) reared rainbow trout to harvest size (200 g) in water heated to 13 C. In 1982, Papst and Hopky (1983) developed a pilot scale commercial production system which utilized a low-grade heat source and water recirculation to rear Arctic charr to harvest size. They concluded that freshwater intensive culture of Arctic charr was biologically feasible.

1.3 ECONOMICS OF AQUACULTURE

The use of waste heat for aquaculture is beneficial because it enhances fish growth (Hambrey 1980). Increased growth rate may increase the value of fish produced at a higher rate than the increase in input costs. Unfortunately, data regarding the relationships between input factors and growth rate or production for waste heat aquaculture of Arctic charr have not been fully documented.

Current economic models in aquaculture have been designed for rainbow trout farms since this type of operation is a major component of the Canadian aquaculture industry (Blum 1979, Jorgani et al. 1984). These economic models are more applicable to the new salmon culture industry in British Columbia than to waste heat aquaculture systems (Bott 1986). For example, it would be impossible to consider the ben-

efits in utilizing increased water temperature without also considering the effect increased temperature will have on food intake and food costs. The economic model developed by Hambrey (1980) is the most applicable one currently available, but he reported that the model is not completely satisfactory due to lack of data on fish growth, metabolism, and water quality. This type of information is required before more comprehensive evaluations of waste heat aquaculture can be conducted (Hambrey 1980).

1.3.1 Government Regulations

The Freshwater Fish Marketing Act (R.S.C. 1970;c. F-13) has authorized the Freshwater Fish Marketing Corporation (FFMC) to act as the sole purchasing and marketing agent for freshwater fish caught commercially in Manitoba (Stankevicius 1985). The jurisdiction of the FFMC extends to the three prairie provinces, N.W.T., and northwestern Ontario. The federal Fisheries Act allows commercial fishermen to sell their catch directly to consumers, but most fishermen market their catch through the FFMC.

Under the Freshwater Fish Marketing Act, the FFMC has been established "for the purpose of marketing and trading in fish, fish products, and fish by-products in and out of Canada". The FFMC, however, has refused to handle any cultured fish produced in Manitoba on a commercial basis, yet has not issued a formal policy regarding processing and marketing of these "fish products". Under the federal Fisheries Development Act, "fishery products" are defined to "include any fishery resources and any products derived from the fishery resources of Canada."

The anticipated high commercial value of cultured Arctic charr may, however, cause a change in the FFMC's position regarding aquacultural products. The current status of this policy should be determined since it would affect the economic evaluation of any commercial Arctic charr production system.

1.4 PROBLEM STATEMENT

In 1984, John Kasenaar, Executive Vice-President of Dominion Malting Limited, contacted the Department of Fisheries and Oceans to express the company's interest in commercially producing Arctic charr. The malting plant, located on Dugald Road in Winnipeg, Manitoba, had an abundant supply of heated well water and a few malting vats which had been removed from production. A growth test was initiated in 1985 at the Dominion Malting plant using one surplus vat and 1200 Arctic charr fingerlings. The growth test proved the pilot scale production system biologically feasible. The subsequent research stage was to develop a commercial scale Arctic charr production system at the plant which utilized the waste heat water supply.

1.5 RESEARCH OBJECTIVES

The purpose of this study was to determine the biological and economic feasibility of commercial Arctic charr production using waste heat aquaculture. The scope of the study was limited to a specific case study on conversion of a malt plant (ie. redirection of existing capital assets) for commercial Arctic charr production. Study objectives were as follows:

1. To identify and assess biological operating criteria (eg. water flow, temperature, ammonia concentration) and those criteria which are limiting factors to the system;

2. To identify and evaluate economic factors for the system (eg. capital investment, fixed and variable costs, regulations);

3. To assess consumer acceptance of cultured Arctic charr and to assess a retailer's acceptance of the product as part of economic feasibility determination; and

4. To recommend strategies for future Arctic charr production using waste heat aquaculture based upon the system's unique constraints and advantages.

Chapter II

METHODS AND MATERIALS

2.1 BIOLOGICAL STUDY

2.1.1 System Definition

The waste heat aquaculture system used in this study was part of the existing Dominion Malting Limited operation on Dugald Road in Winnipeg, Manitoba.

Water was supplied to the operation by an outside well. Incoming well-water of 4.5 C was mixed with 40-45 C water from heated storage tanks to obtain the 15 C water pumped to the malting vats. Analysis indicated that water quality was suitable for aquaculture. Heated water to the vats was tapped off a main line and entered each vat by a pipe (Figure 1). A flow meter was situated on each line to monitor water flow, which had been set at 9 litres/minute. Approximately 17 days were required for complete water turn-over in each vat. A separate cold water line was installed during growth trial 2 to reduce the possibility of water temperatures exceeding 17 C in the summer months (Table 4).

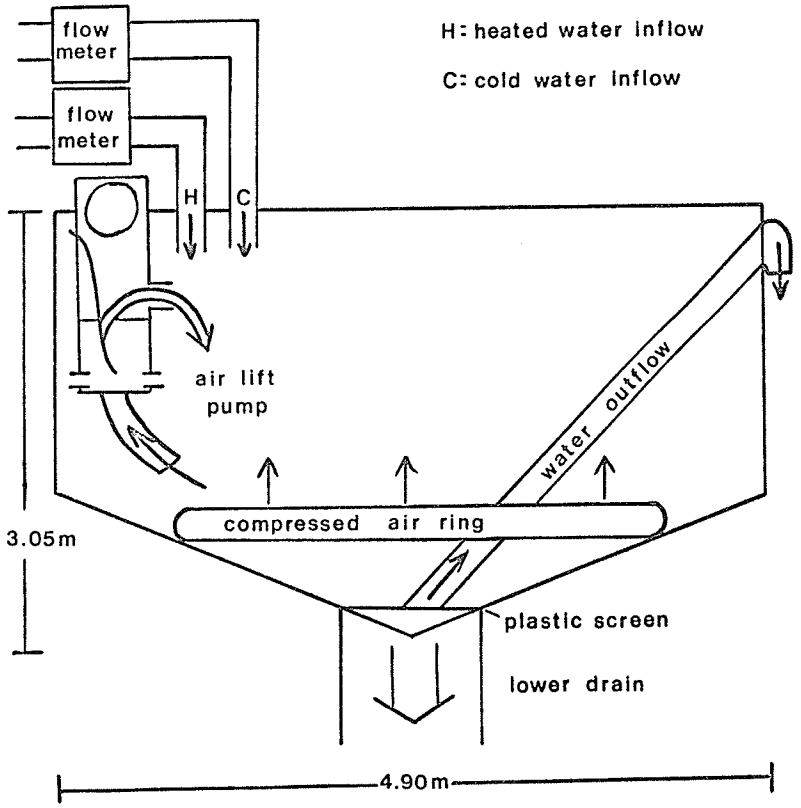


Figure 1: Schematic diagram of malting vat used for commercial Arctic charr production.

TABLE 4

Malt plant equipment used in study.

Equipment Present Before Study	Equipment Added For Study
Pipe and flow meter for incoming heated water	Pipe and flow meter for incoming unheated well water
Compressed air ring	Air lift pump
Upper outflow drain (overflow)	Lower drain siphon system which emptied into upper outflow drain
Air compressor	Perforated plastic screen for lower drain
Boiler	
Water piping system	
Heated water storage tanks	Nylon mesh cover for vat
Well	
	Low-water alarm

Each steel vat measured 3.05 meters by 4.90 meters and held a total of 28,310 litres (6,250 gallons) (Figure 1). Non-toxic, red rubber tile coated the inside of each vat and a heavy, plastic screen was positioned over the lower drain to prevent fish loss during draw-down or harvest (Figure 1). A nylon mesh cover and low-water alarm was also used on each vat to prevent fish loss.

Compressed air was supplied to each vat through an air ring (Figure 1). An air-lift pump was also used to aid water circulation and to maintain a recommended dissolved oxygen level of 5.0 mg/l (Meyer et al. 1983).

Water was drained from the vat continuously by a siphon system near the lower drain at a rate of 9 litres/minute (Figure 1). The vat was

"flushed", or had the water level drawn down, twice daily and the water discharged into the Winnipeg sewer system. Discharged water met City of Winnipeg effluent standards.

2.1.2 Growth Trials

Nauyuk Lake Arctic charr fingerlings were used in this study. This strain, derived from anadromous stock, is produced at the Rockwood Experimental Fish Hatchery (Papst and Hopky 1984). The hatchery is located approximately 65 km north of Winnipeg, Manitoba.

Three independent growth trials, or production runs, were conducted at the malting plant. Trials 1, 2, and 3 used 1200, 2500 and 4000 Arctic charr respectively. Given the small water flow rate of this production system, the three growth trials were conducted to assess the system's performance when low, medium and high loading rates were used.

Charr were sampled bi-weekly during each growth trial by a batch method to determine weight changes. Fish were hand fed 3 times per day, at approximately 75% of the ration recommended in published tables for rainbow trout (Bardach et al. 1972), with the amount corrected for changes in fish size as determined by the bi-weekly weight census. Mortalities were collected and recorded whenever possible. Water temperature was monitored by an automatic recorder during each growth trial.

2.1.3 Growth Calculations

Since there was no vat replication in any of the growth trials, the Coefficient of Variation was determined for a charr sample at the beginning and end of a trial and reported as a percent. Coefficient of Variation is defined as:

$$V = \frac{Sd}{Y} \times 100$$

where Sd is the standard deviation and Y is the mean.

Specific growth rates were calculated using mean batch weights from the bi-weekly census, by:

$$G = \frac{\ln W_t - \ln W_{(t-1)}}{T_t - T_{(t-1)}} \times 100$$

where W is wet weight, T is time in days and G is expressed as a percent of body weight per day (Ricker 1975).

2.1.4 Water Chemistry

Replicated water samples were taken from the vat on a twice-weekly schedule. Specially designed 300 ml glass bottles with ground glass stoppers were used to collect water from the surface and 0.5 m below surface for dissolved oxygen determination. These samples were treated with manganese sulphate and iodide azide (4 ml per sample) on site to prevent sample deterioration. Plastic 500 ml bottles were used to collect water samples from the surface and outflow for ammonia, nitrite, and pH determination. Water samples were randomly taken from the inflow.

Water sampling was conducted at regular intervals over two days to test the the effectiveness of draw-down on reducing concentrations of ammonia and nitrite in the vat.

Concentrations of ammonia, nitrite and dissolved oxygen were determined manually by methods described by Stainton et al. (1974). The pH of each water sample was measured by an electronic probe/pH meter. Water samples were sent to the Freshwater Institute Chemistry Laboratory for nitrate determination. Ammonia, nitrite and nitrate concentrations were expressed as micrograms per litre (ug/l) and dissolved oxygen as milligrams per litre (mg/l).

2.1.5 Cultured Charr Analysis

As part of the post-harvest evaluation of quality, samples of cultured Arctic charr were submitted to the Regional Chemist with the Department of Fisheries and Oceans for chemical analysis. Three fish, weighing 202 g, 244 g, and 346 g respectively, were analyzed for pesticide and metals content and proximate composition. Results of the pesticide scan, metals analysis, and proximate composition determination were expressed in ppb, ppm, and percent weight respectively.

2.2 ECONOMIC STUDY

2.2.1 Economic Analysis

The waste heat aquaculture enterprise consisted of 4 vats, scaled up from data obtained during operation of one vat. The highest loading rate determined for the system was used to maximize economic returns.

The company considered its aquaculture enterprise to be a component in the existing malt operation. Items such as taxes, insurance, rents and leases were paid by the main operation and therefore, were not attributable to the aquaculture enterprise. Only fixed and variable costs directly resulting from the aquaculture enterprise were considered in the analysis. Economic factors such as seasonal availability of charr fingerlings and feed were also considered.

Required capital investment for the venture was estimated and an income statement for one production cycle was calculated to assess economic feasibilty. Economic data was collected by correspondence and personal interviews. Results were expressed as dollar amounts.

2.2.2 FFMC Policy

The Freshwater Fish Marketing Corporation's policy on Arctic charr aquaculture was determined through a personal interview with the Director. The interview consisted of questions pertaining to licensing of commercial aquaculture operations and the processing and sale of cultured Arctic charr.

2.3 CONSUMER SURVEY

2.3.1 Cultured Arctic Charr

Arctic charr used for this survey were produced at the Rockwood Experimental Fish Hatchery and at Dominion Malting Limited. Charr were harvested at 200-250 g, processed at the Freshwater Institute, and packed in 50 lb boxes on ice. Fish were sold fresh, dressed with head

on. In total, 189 kg of cultured Arctic charr were sold to Canada Safeway Limited for $11.03 per kg. Safeway subsequently marketed the charr at $3.99 per fish, or $16.00 per kg.

Arctic charr produced at the hatchery were only used to supplement the quantity sold to Safeway. They were not included in the economic analysis of the Arctic charr production system at Dominion Malting Ltd.

2.3.2 Survey Area

The cultured charr were sold from Safeway stores in the Winnipeg area that featured full-service fish counters. For distributional purposes, Safeway has divided the city into two divisions: north and south. The hatchery reared charr went to 4 northern stores: Sargent and Maryland; Polo Park Shopping Centre; Garden City Mall; and Burrows and Keewatin. The Arctic charr produced at the waste heat aquaculture site were sent to 5 southern stores: 2155 Pembina Highway; 1225 St. Mary's Road; Vermillion Road; 2025 Corydon Avenue; and Forest Park Mall.

2.3.3 Consumer Survey Design

The survey questions were structured around five areas: income; lifestyle; price; product; and demographics. Appendix A contains a copy of the survey as it was presented to consumers.

Direct and indirect questions regarding income were included in the survey design to determine the income level(s) of consumers who pur-

chased the cultured charr. Income data were necessary in defining the consumer market for cultured Arctic charr.

Lifestyle questions were intended to probe consumers' shopping habits with regard to fish and seafood. Lifestyle data were also necessary in defining the consumer market for cultured charr and for advertising applications.

Price questions were present in the survey to assess consumers' willingness to pay for fresh and frozen fish, and thereby determine the demand side of the market for fish. Specific price questions related to the product were included to assess consumers' willingness to pay for cultured Arctic charr.

Questions regarding the product comprised the bulk of the consumer survey. Consumers were asked to rate the size, appearance, raw flesh colour, flavour and texture of the cultured charr.

Standard demographic questions were used in the survey to identify age and ethnic groups of cultured charr consumers.

A decision was made not to have distinctly numbered sections in the consumer survey, but rather, to have a homogeneous series of questions. Hence, the survey questions were not in any particular order, except those which pertained to the product. Some of the survey questions were "placebos".

All consumer surveys were coded for the nine stores and packaged in postage-paid envelopes. A total of 600 consumer surveys were distributed to the Safeway stores.

2.3.4 Conducting the Survey

Advance notification of the consumer survey was sent in a memorandum by Canada Safeway Limited to the fish counter managers of the nine stores. One day prior to the arrival of the charr shipment, I travelled to each of the nine stores to inform fish counter personnel that a survey was to be given to each customer who purchased a cultured charr. Fish counter personnel were also asked to encourage customer participation in the survey. Comments of Safeway executives, managers and personnel were noted whenever possible. This information was used to determine the retailer's acceptance of cultured Arctic charr.

2.3.5 Analysis

For each survey question, the toal number of responses for each answer, including "no response", were added and converted to a percent. It was decided to include all answers in the analysis, rather than discount consumers who expressed more than one opinion. Hence, the total percentage on some questions exceeded 100%. For such questions, individual percentages were recalculated by the computer graphics program so as to total 100%. Survey results were expressed as percentages.

Chapter III

RESULTS

3.1 BIOLOGICAL STUDY

3.1.1 Growth

The 1200 Arctic charr fingerlings in Trial 1 grew from a mean weight of 32.60 g to a mean weight of 164.90 g in 165 days (Figure 2). Mean specific growth rate was 1.05%/day. Water temperature fluctuated slightly around 15 C for the duration of the production run (Figure 3).

Unlike Trial 1, the next two trials did not go to completion with full complements of fish. In both trials, fish kills resulted from accidental vat drainage. Trial 2 experienced a loss of approximately 2000 charr, while Trial 3 lost 3600 fish.

Despite the fish kill, only 105 days were required for the charr fingerlings to grow from a mean starting weight of 26.75 g to a mean end weight of 187.96 g in Trial 2 (Figure 4). The mean specific growth rate for this trial was 2.12%/day. Water temperature fluctuated between extremes of 12-18 C during this growth trial (Figure 5).

In Trial 3, 150 days were required for the charr to grow from a mean starting weight of 25.08 g to a mean end weight of 224.80 g (Figure 6). Mean specific growth rate for this run was 1.93%/day. The

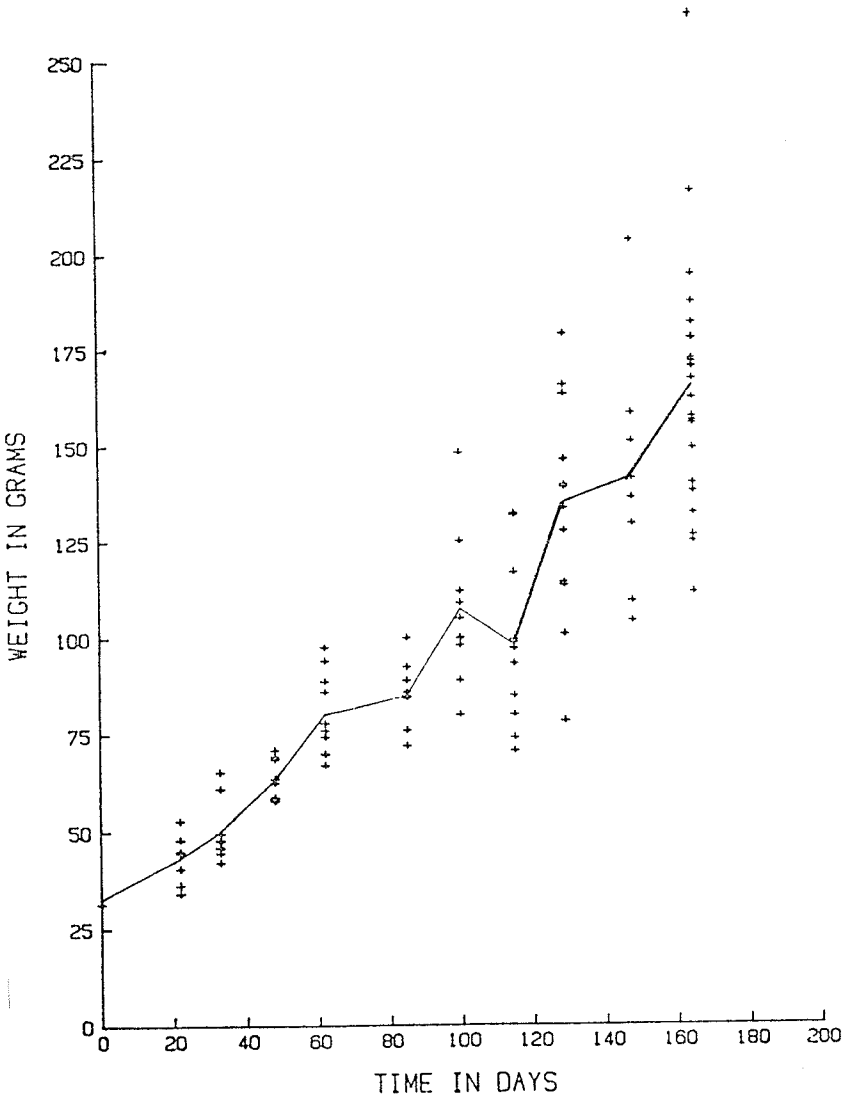


Figure 2: Changes in mean live weight of Arctic charr in growth trial 1. Crosses represent mean batch weights. Line indicates mean weight for the sample.

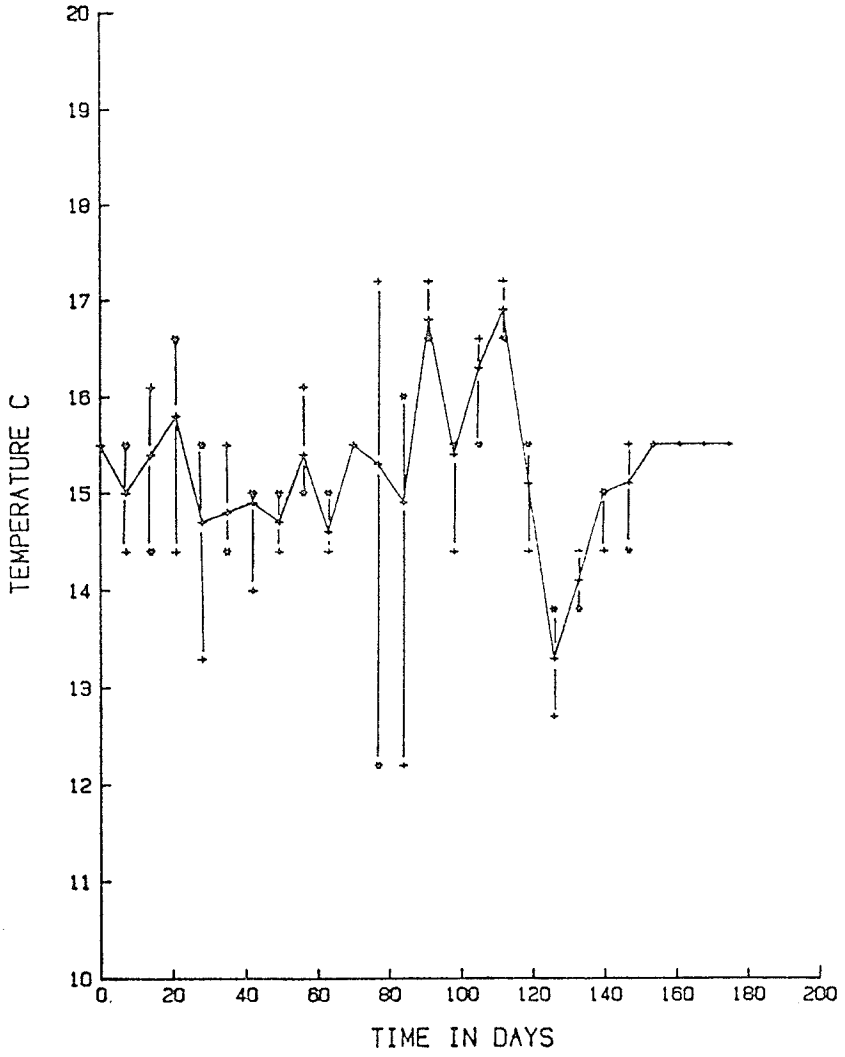


Figure 3: Mean water temperatures during growth trial 1. Vertical bars represent observed temperature range.

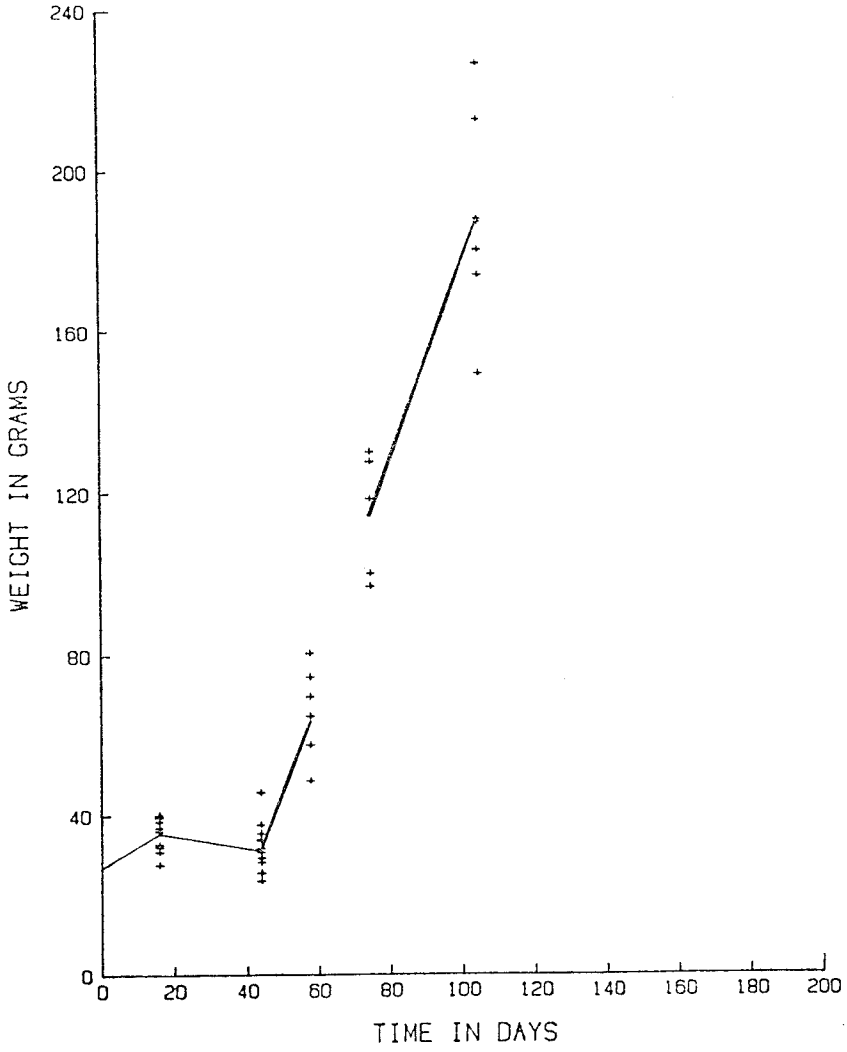


Figure 4: Changes in mean live weight of Arctic charr in growth trial 2. Crosses represent mean batch weights. Line indicates mean weight for the sample.

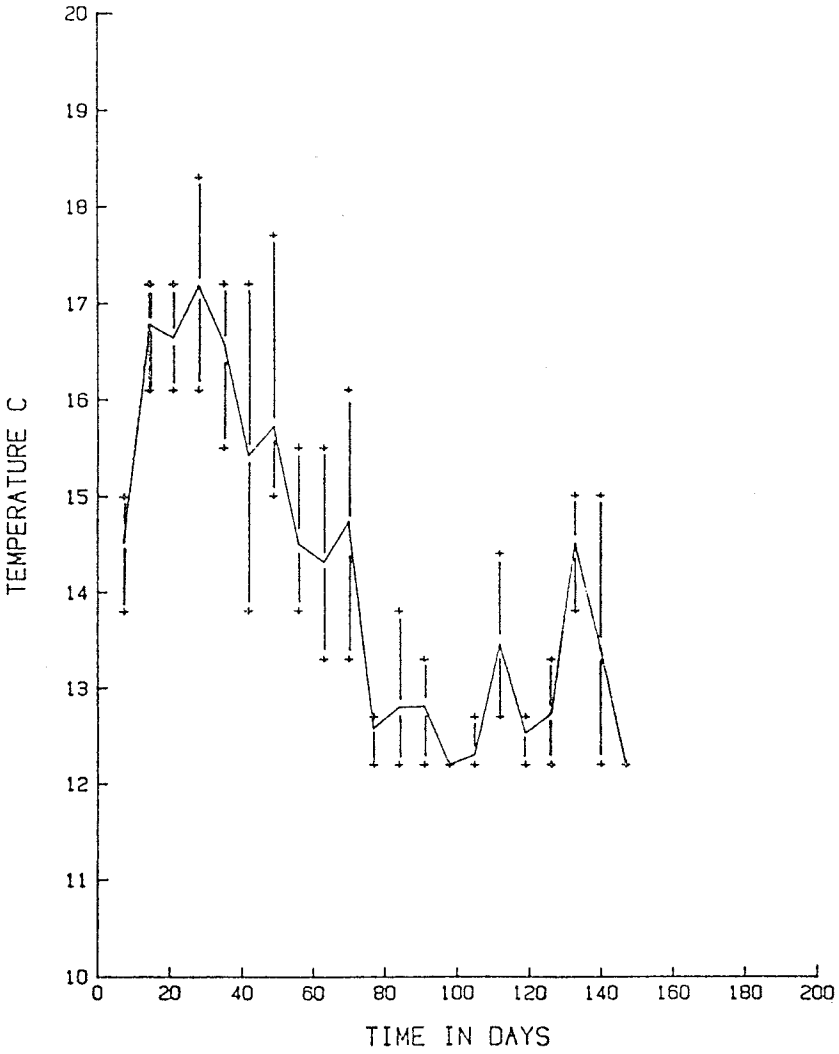


Figure 5: Mean water temperatures during growth trial 2. Vertical bars represent observed temperature range.

Coefficient of Variation at the beginning and end of Trial 3 were 33.27% and 56.86% respectively (Figure 7). Figure 7 illustrates the bimodal size distribution of the charr observed at the time of the fish kill, 60 days after the start of the production run. Water temperature was recorded only for the first 60 days of this trial, but the mean temperature was 14±1 C (Figure 8).

Given the small water flow rate and concentrations of ammonia and nitrite which approached maximum acceptable water chemistry limits, 4000 Arctic charr were close to the maximum number of fish that could be stocked in the system (ie. loading rate).

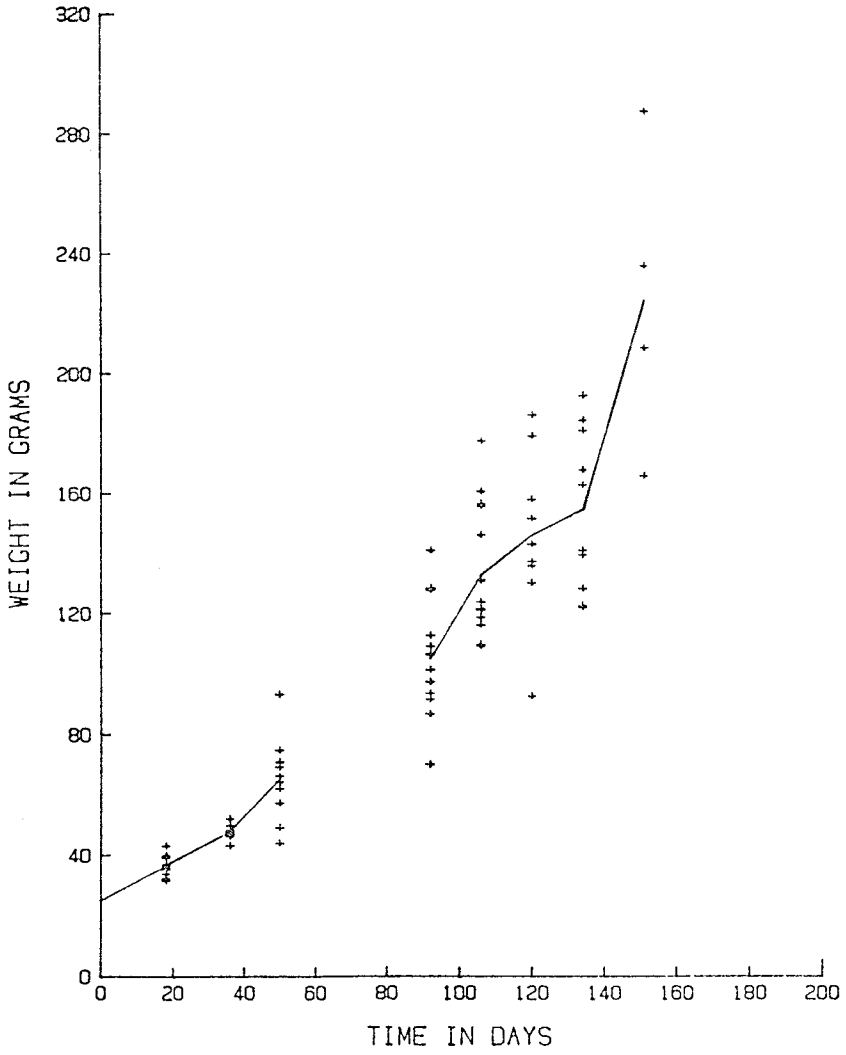


Figure 6: Changes in mean live weight of Arctic charr in growth trial 3. Crosses represent mean batch weights. Line indicates mean weight for the sample.

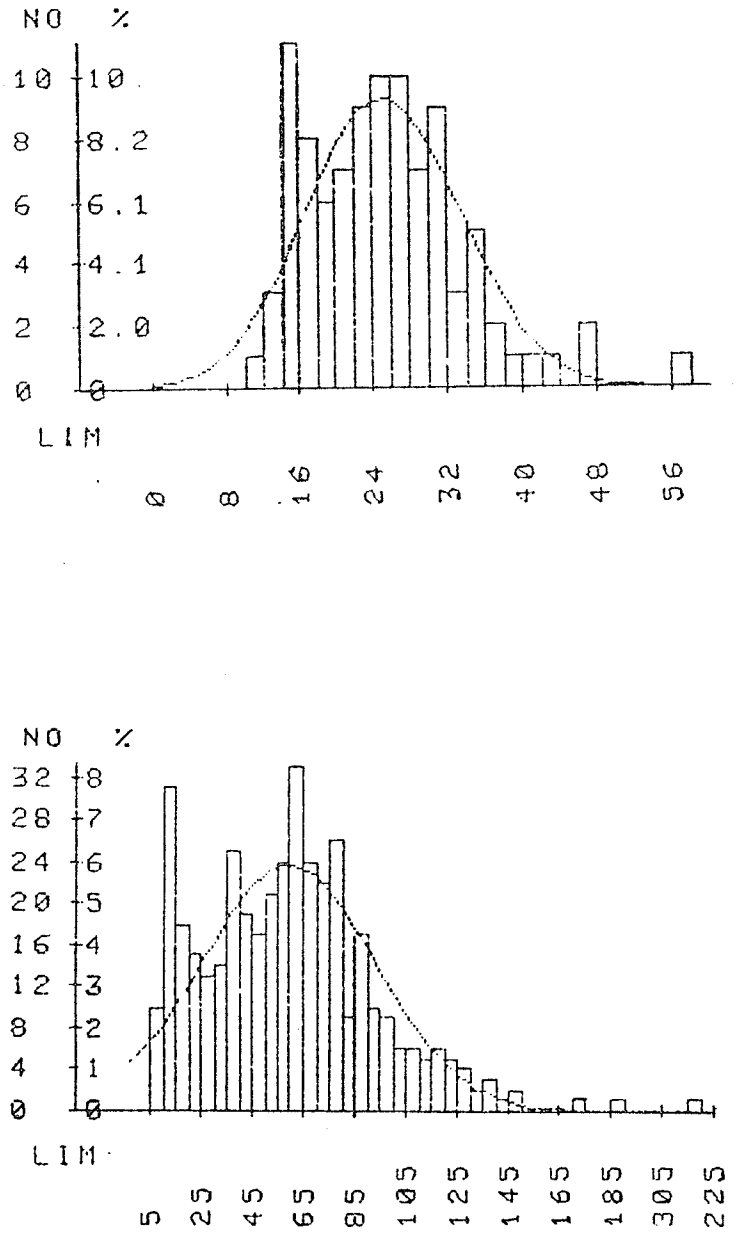


Figure 7: Size distribution of Arctic charr at start (top) and end (bottom) of growth trial 3.

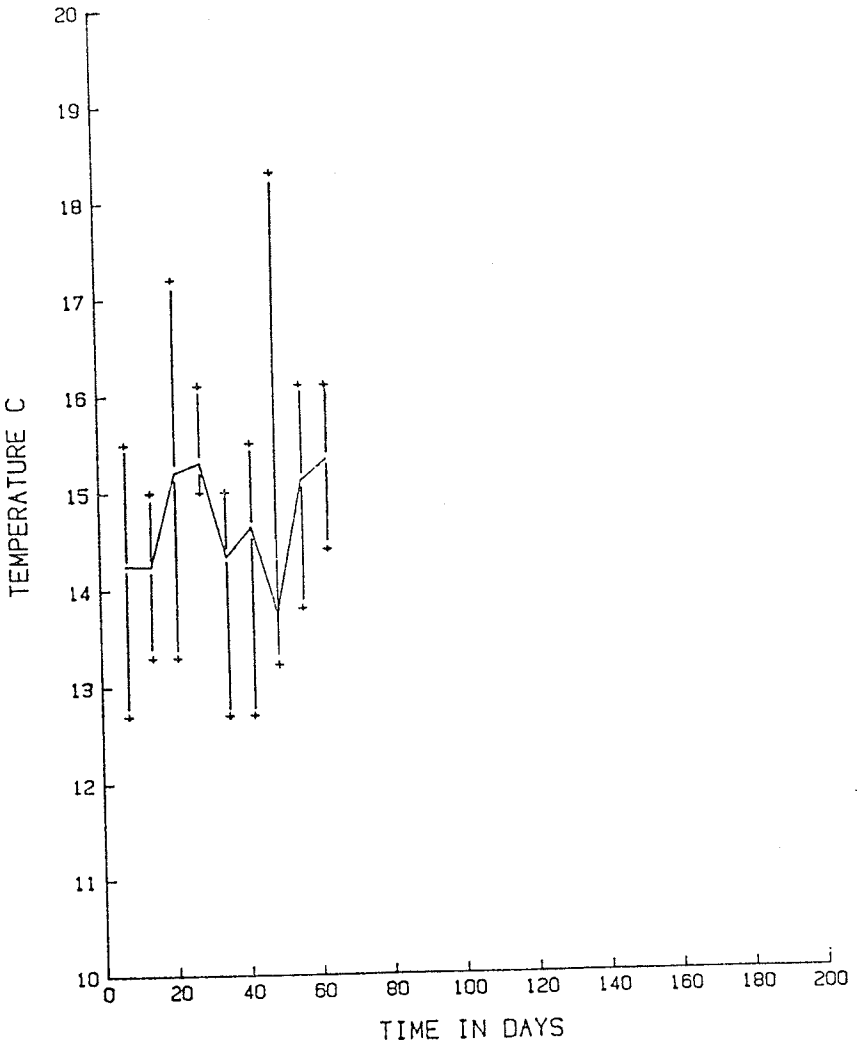


Figure 8: Mean water temperatures during growth trial 3. Vertical bars represent observed temperature range.

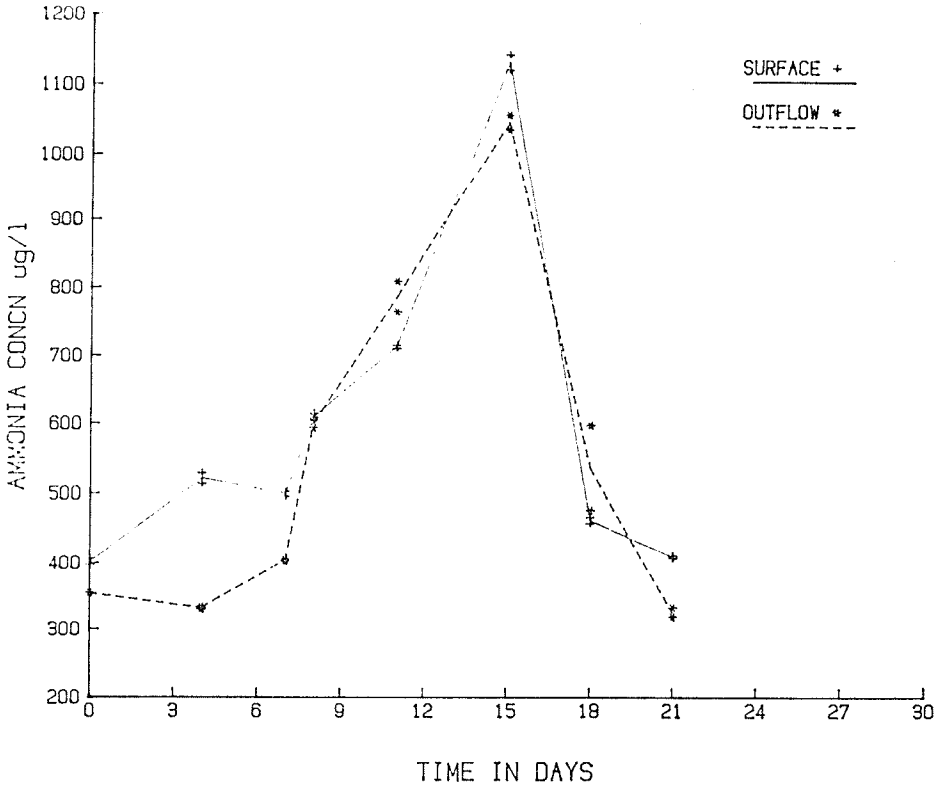
3.1.2 Water Chemistry

Figure 9 illustrates the pattern of ammonia and nitrite concentration in the vat during growth trial 3, when fish density was greatest. Ammonia concentration on the water surface increased from 402 ug/l to 1134 ug/l in 15 days, then decreased to 409 ug/l in the 6 days that followed. A similar pattern was observed with samples of outflow water (Figure 9). Similarly, the nitrite concentration on the surface increased from 309 ug/l to 540 ug/l in 18 days, then decreased to 241 ug/l (Figure 9). Nitrite concentration in outflow samples displayed a similar pattern (Figure 9).

During growth trial 3, the pH of surface and outflow samples fluctuated between 7.6 and 8.1 (Figure 10). Dissolved oxygen increased from 3.25 mg/l to 6.55 mg/l in surface water samples during the same time period (Figure 10). Oxygen readings were consistently higher when taken 0.5 m below surface (Figure 10).

Nitrate concentration in outflow samples increased from 170 ug/l to 1380 ug/l in two weeks during growth trial 3 (Figure 11).

During the first day of the 2-day sampling period, when draw-downs and feedings were conducted as normal, the surface concentrations of ammonia and nitrite increased to 500 ug/l and 684 ug/l respectively (Figure 12). Ammonia and nitrite concentrations in outflow samples displayed a similar pattern (Figure 12). On the second day, when feedings were regular and no draw-downs were conducted, the surface concentrations of ammonia and nitrite increased to 755 ug/l and 700 ug/l respectively (Figure 12). Ammonia and nitrite concentrations in outflow samples displayed a similar pattern (Figure 12).



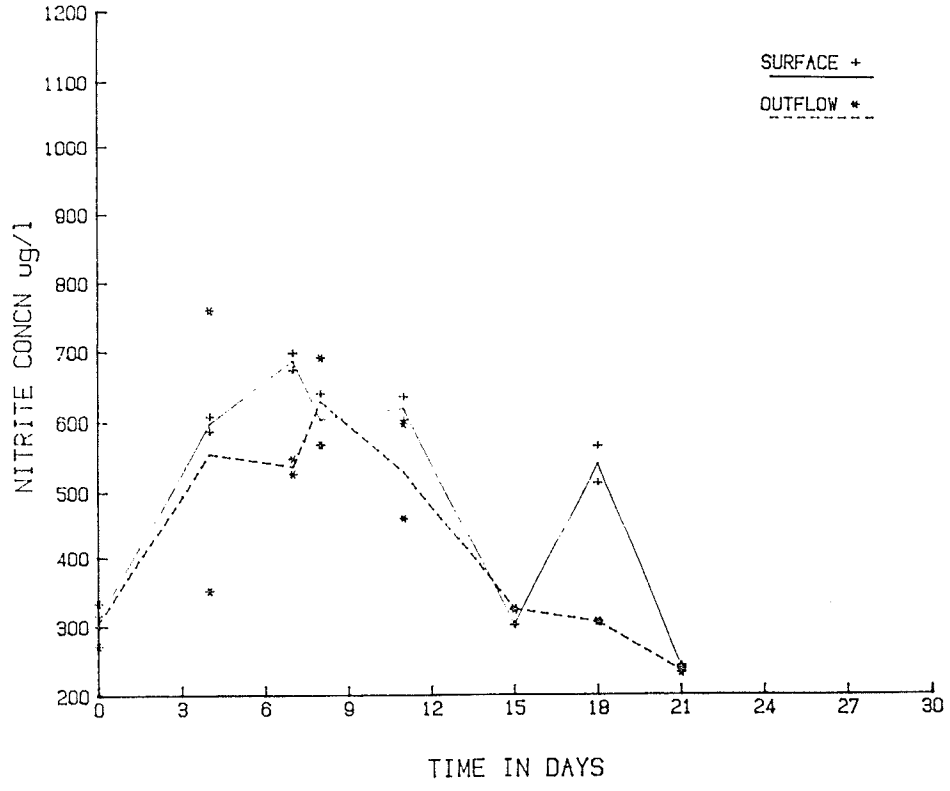


Figure 9: Ammonia and nitrite concentrations during growth trial 3 (05/05/86-26/05/86).

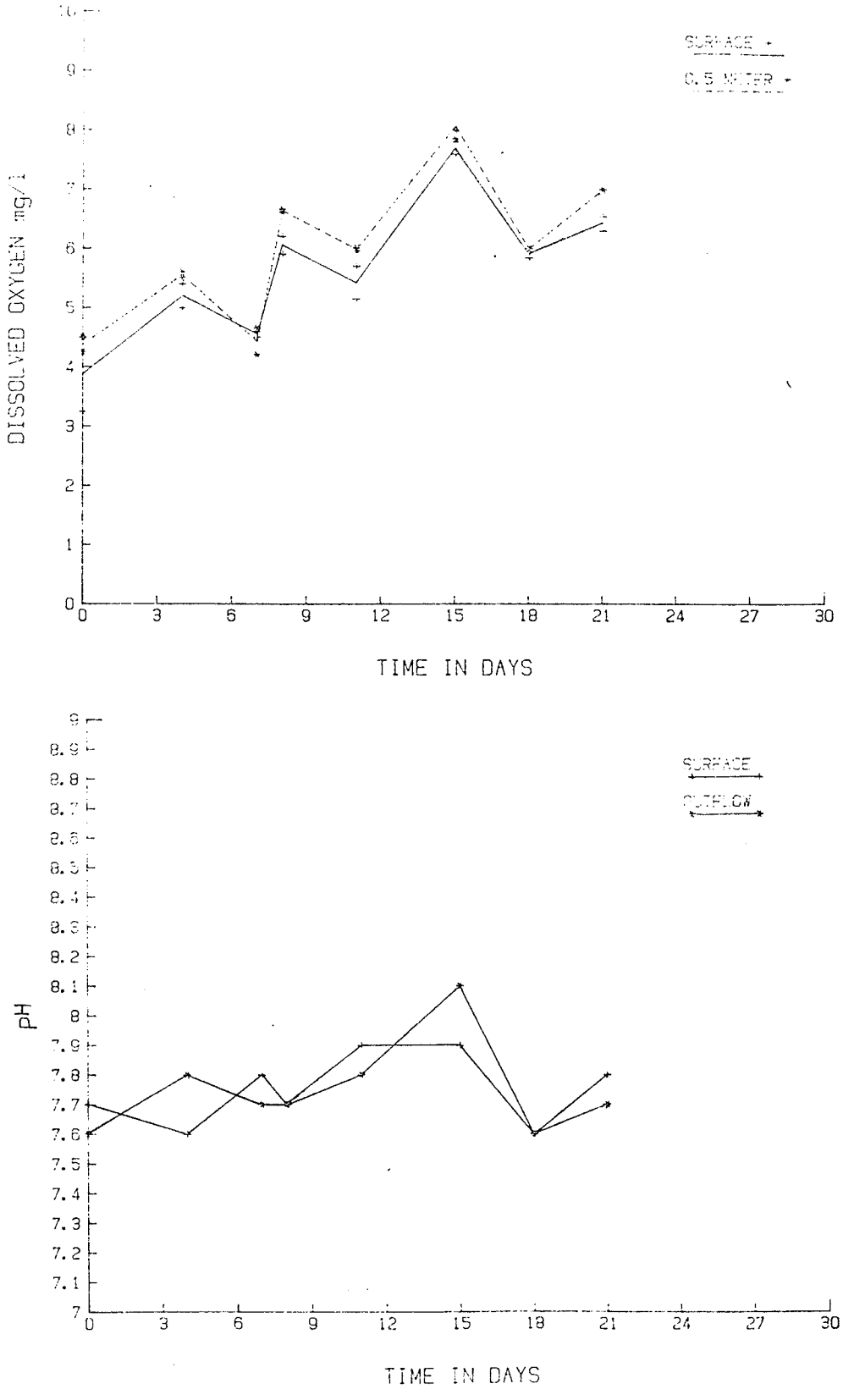


Figure 10: Dissolved oxygen concentration and pH during growth trial 3 (05/05/86-26/05/86).

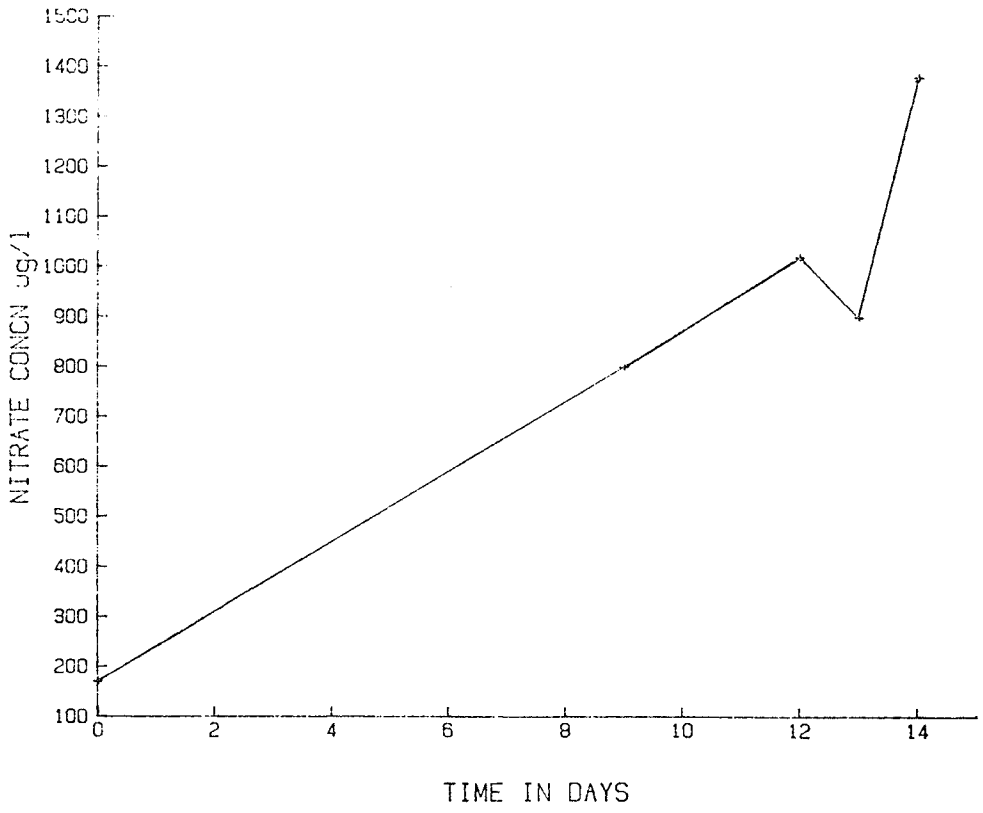


Figure 11: Nitrate concentration during growth trial 3 (30/04/86-14/05/86).

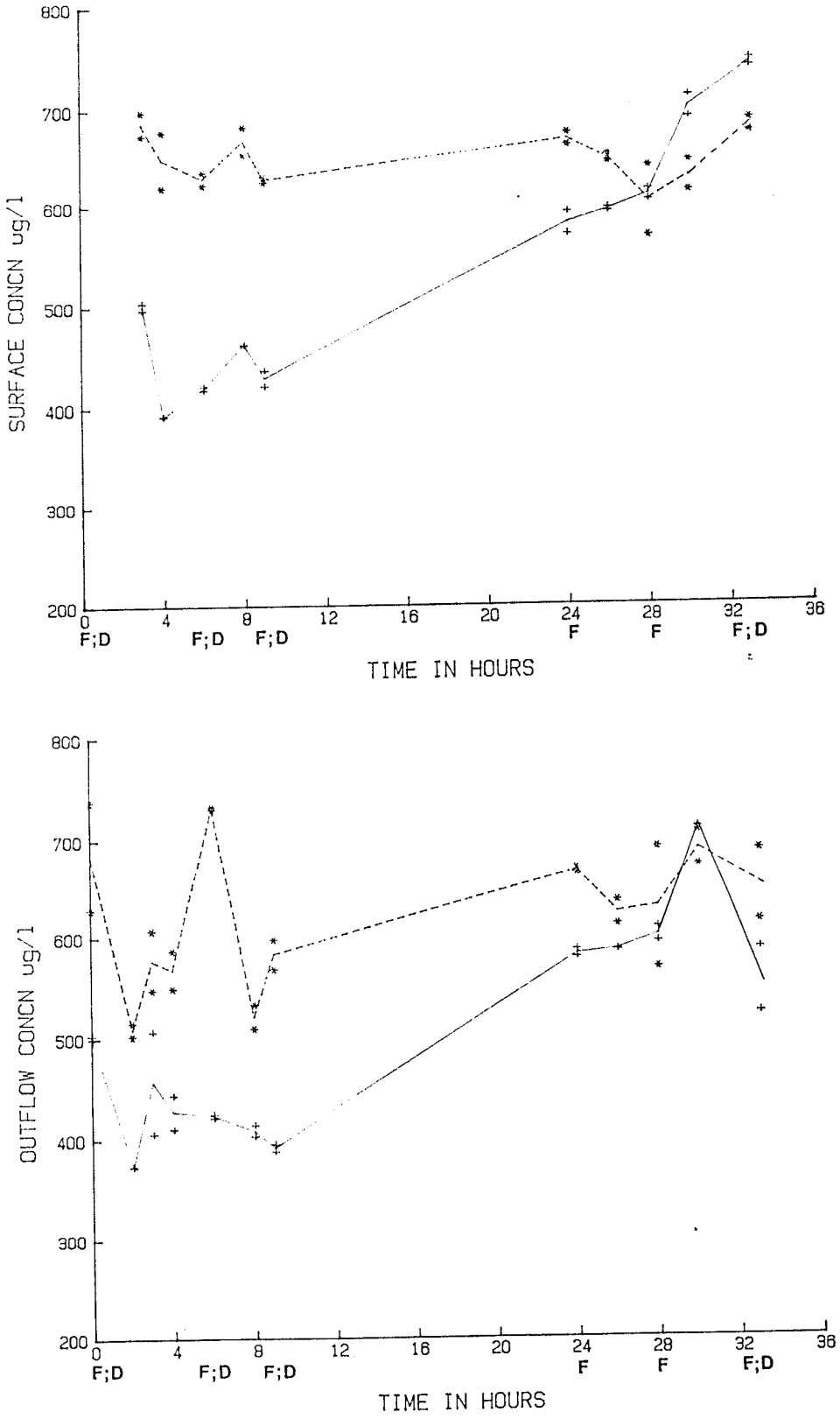


Figure 12: Results of 2-day water sampling during growth trial 3 (12/05/86-13/05/86).

3.1.3 Cultured Charr Analysis

For the contaminants tested, none of the levels reported were considered significant from a human health perspective (Appendix B). Levels of DDT and PCB were 6-13 and 41-60 ppb respectively. Mercury was measured to be 0.03 ppm in the cultured charr samples and the level of lead was determined to be <0.01 ppm.

The proximate composition analysis indicated that lipid content of the cultured charr increased with increasing weight, while protein content was constant at 21%. Moisture and ash content were similar in all 3 samples of charr.

3.2 ECONOMIC STUDY

3.2.1 Economic Analysis

This Arctic charr aquaculture enterprise generated $3,457 as a gross net return on an estimated capital investment of $15,771 (Tables 5 and 6). It must be remembered that the $3,457 is not profit, but rather, is economic return on fixed and variable costs as measured. The price which the company must receive to break even, or have a zero gross net return, is $9.75/kg. Data and calculations for estimated capital investment, annual fixed cost, and income statement are presented in Appendix C.

TABLE 5

Estimated capital investment for the waste heat aquaculture enterprise.

4 VAT CONVERSIONS:	
New drain and air lines (ie. air flow pump) Valve replacement New cold water lines Water meters	$ 718.94
Low-water alarm systems	800.00
Labour (Union rate = $16.50/hr)	3,036.00
BASIC LAB EQUIPMENT:	
Water bottles, oxygen kit, mechanical stirrer, glassware, chemicals	250.00
HARVEST EQUIPMENT:	
30 blue heavy-duty plastic bins	706.20
2 handnets, plastic garbage pails	100.00
240 re-usable corrugated cardboard fish boxes	2,160.00
1 ice machine	1,000.00
1 used half-ton truck	7,000.00
TOTAL CAPITAL INVESTMENT	$15,771.14
FIXED COSTS:	
Annual loan payment (includes 10% interest) on capital investment	$ 1,735.00

TABLE 6

Income statement for one Arctic charr production cycle (165 days) at Dominion Malting Ltd.

WASTE HEAT AQUACULTURE ENTERPRISE

INCOME DATA:

Supermarket sales	
Fresh ($11.03/kg)	$29,781.00
Frozen ($8.82/kg)	0.00
Restaurant sales	0.00
Export sales	0.00
TOTAL INCOME	$29,781.00

EXPENSE DATA (VARIABLE):

Labour	
Full-time Aquaculturist	$12,500.00
Part-time general labour (Union rate)	1,536.00
Purchased feed	3,858.15
Purchased fingerlings	3,200.00
Water quality testing fees	119.60
Water discharge (sewer fees)	2,526.88
Compressed air	10.00
Heating (water)	2.84
Processing	685.28
Transportation	50.00
Administrative costs (phone, office supplies,etc)	100.00
TOTAL EXPENSES	$24,588.75

NET RETURN ON CAPITAL INVESTMENT =	$5,192.25
ANNUAL FIXED COST =	$1,735.00
GROSS NET RETURN =	$3,457.25

3.2.2 FFMC Policy

Currently, the FFMC only processes Arctic charr caught commercially in the N.W.T. and in the 0.9 - 5.5 kg size range. It is FFMC policy to license rainbow trout farms in Manitoba and presumably would license Arctic charr producers. With respect to a specific FFMC policy on cultured Arctic charr, the Director emphasized that "it was their policy not to have a policy." He later confirmed that the FFMC was planning to release a formal policy on aquacultural products.

3.3 CONSUMER SURVEY

A total of 34 consumer surveys were returned from the nine Safeway stores: 28 from the southern division and 5 from the northern division (Table 7). This represents a return rate of 9.3% and 1.7% respectively. While it is not a statistically significant result, it is acceptable by DFO standards since no other market data on cultured Arctic charr exist (D.G. Iredale, pers. comm.). Cultured charr from Dominion Malting and rockwood Hatchery could not be accurately compared because of the low return rate from the northern division. As a result, only surveys returned from southern stores were used in the analysis. Survey results are listed according to division in Appendix D.

TABLE 7

Distribution of returned consumer surveys.

Store No.	Location	No. of Surveys Returned
1	Sargent & Maryland	2
2	Polo Park	2
3	Garden City	0
4	Burrows & Keewatin	1
5	Pembina Highway	4
6	St. Vital	3
7	Southdale (Vermillion)	1
8	Corydon Avenue	4
9	Forest Park Mall (Charleswood)	16
		33

3.3.1 Income

Fifty percent of southern respondents indicated an average annual household income over $45,000 (Figure 13). Twenty-one percent of the households had an average annual income between $30,000-$45,000 and only 7% had incomes between $5,000-$15,000. Of southern respondents, 71% were households without children.

Forty percent of northern respondents indicated an average annual household income between $30,000-$45,000 and 40% had incomes which exceeded $45,000 annually (Figure 14). Eighty percent were households without children.

QUESTION: What is the Average Annual Income of your Household?

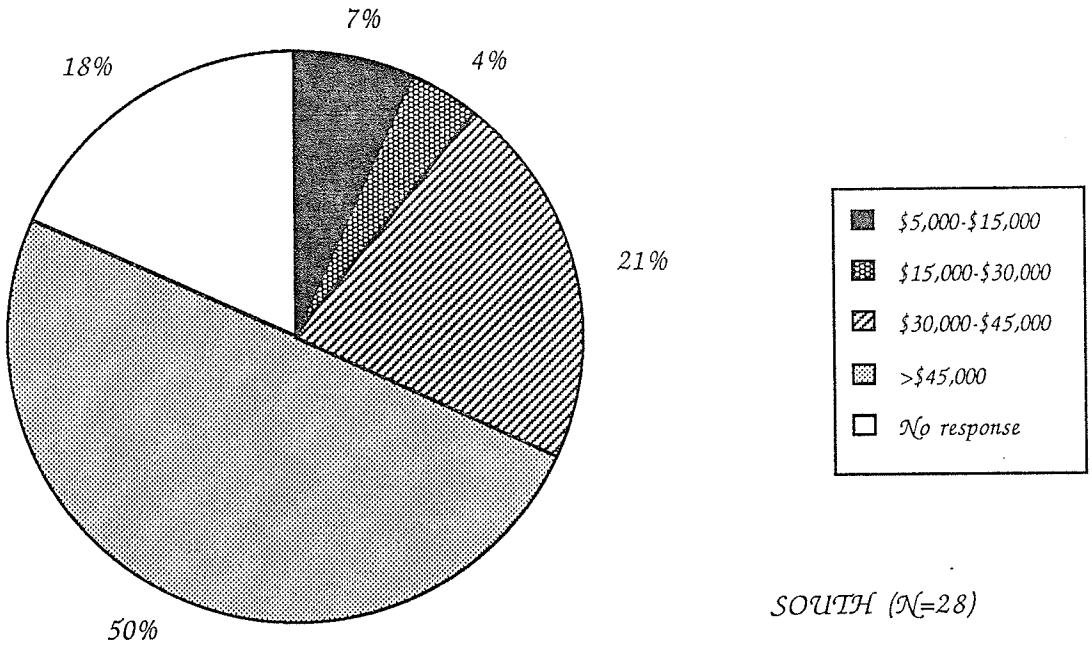


Figure 13: Income distribution of southern respondents in consumer survey.

QUESTION: What is the Average Annual Income of your Household?

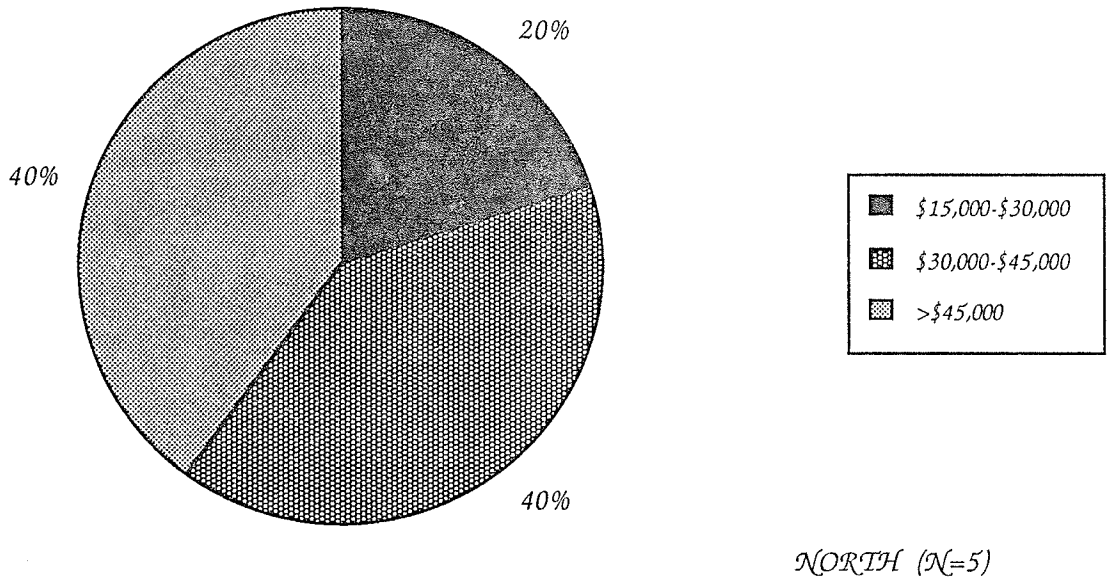


Figure 14: Income distribution of northern respondents in consumer survey.

3.3.2 Lifestyle

Almost all of the respondents shopped for fish at a supermarket, while 10% went to smaller specialty shops (Figure 15). Fifty-seven percent of respondents purchased fresh fish more than once a week (Figure 16), and 46% of respondents purchased frozen fish less than once a month (Figure 17).

Thirty-eight percent of respondents entertained at home less than once a month, but the majority of respondents used fish products when entertaining (Figure 18).

During the past year, the most frequently purchased fish and seafood products were: fresh salmon (86%); fresh shrimp (68%); canned salmon (54%); fresh Pickerel (54%); fresh Whitefish (46%); and fresh rainbow trout (43%) (Table 8).

QUESTION: Where do you Usually Shop for Fish?

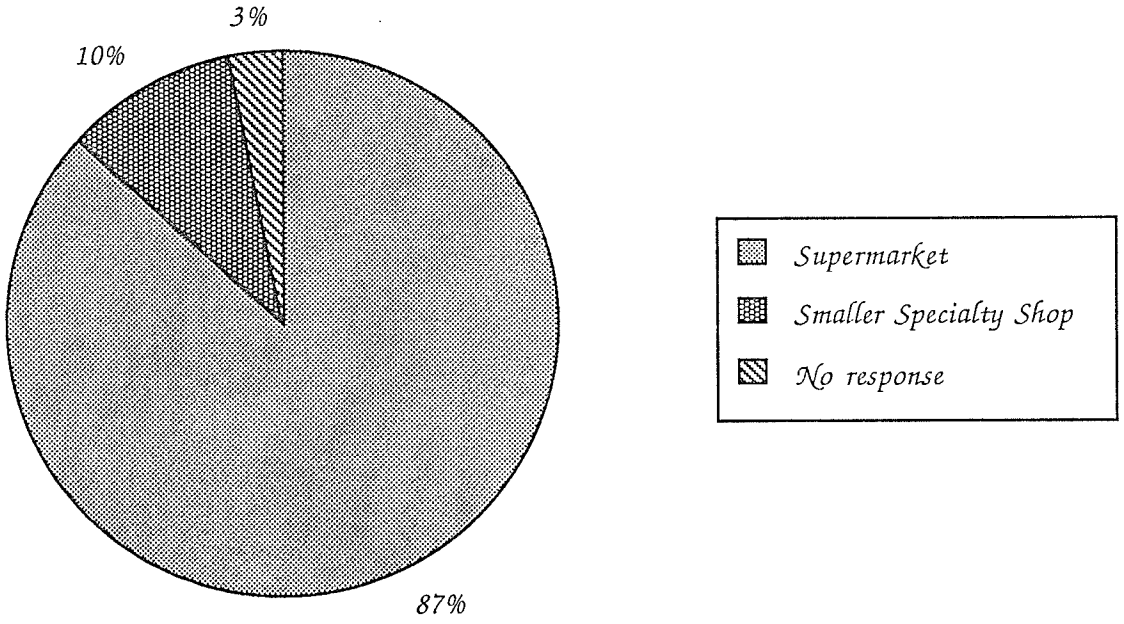


Figure 15: Shopping habits (lifestyle) of respondents in consumer survey.

QUESTION: How often do you purchase Fresh Fish?

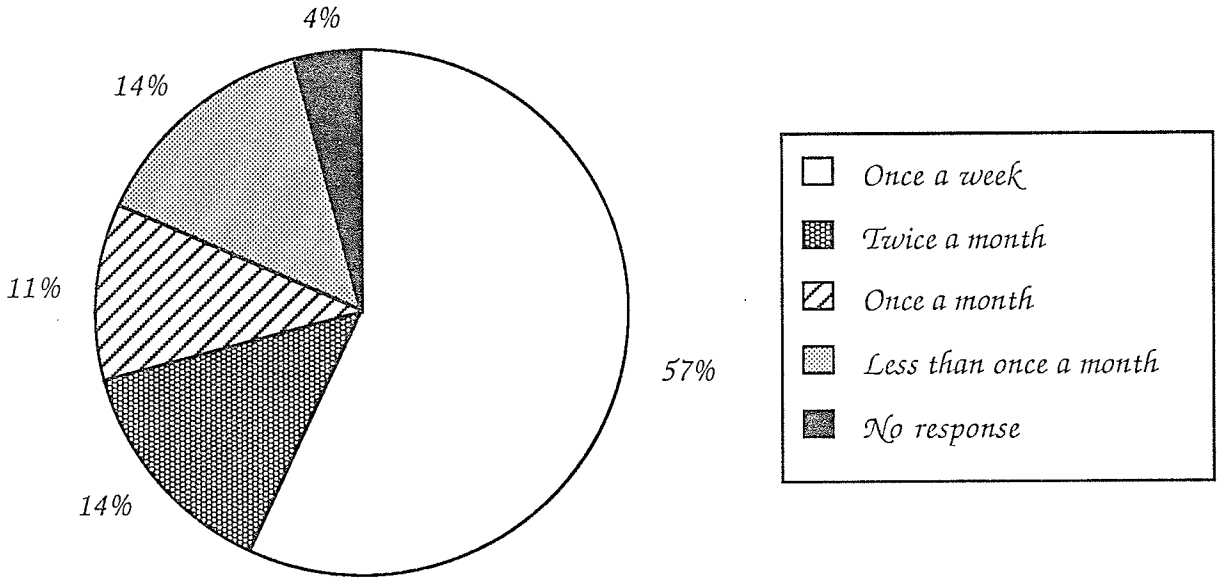


Figure 16: Shopping habits (lifestyle) of respondents in consumer survey.

QUESTION: How often do you purchase Frozen Fish?

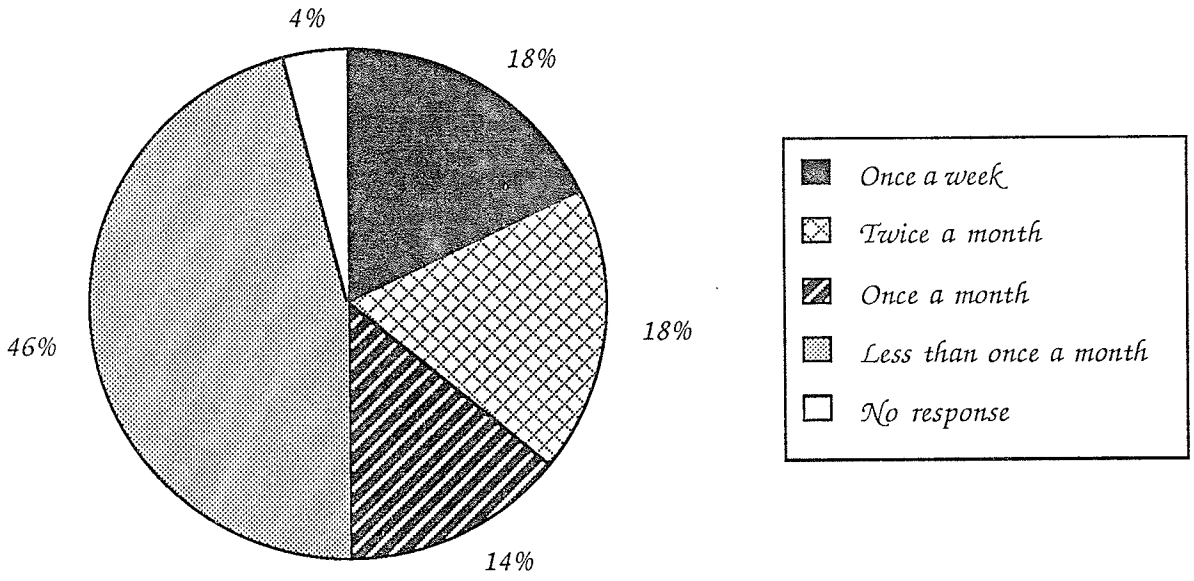


Figure 17: Shopping habits (lifestyle) of respondents in consumer survey.

QUESTION: How often do you Entertain in Your Home?

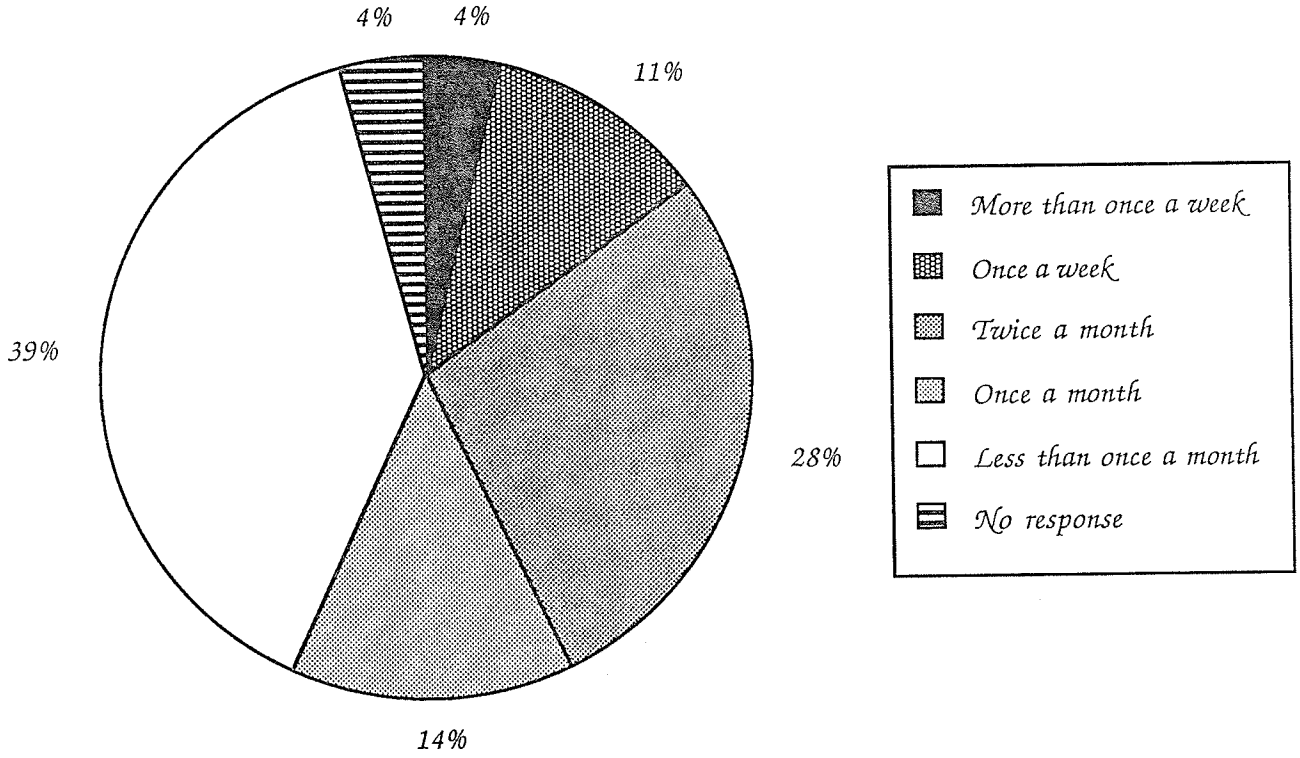


Figure 18: Lifestyle of respondents in consumer survey.

TABLE 8

Fish and seafood items consumers have purchased in the past year.

PRODUCT	FRESH	SMOKED	FROZEN	CANNED
Whitefish	13			
Salmon	24	6	6	15
Tuna	2			20
Mackerel	1			
Rainbow trout	12		4	1
Arctic charr (not introductory product)	10		2	
Goldeye	5	9		
Tullibee	0	1		
Northern Pike	3			
Pickerel	15		9	
Cod	6		6	
Perch	5			
Catfish	1			
Red Snapper	12			
Lingcod	1			
Frog's legs			1	0
Mussels	7	1		1
Oysters	12		0	5
Clams	7			4
Lobster	11			
Crab	6		2	8
Scallops	12		6	
Shrimp	19		11	12
Squid	4			0

Note: Data illustrated are the number of responses received.

3.3.3 Price

Forty-eight percent of respondents usually paid between $9.00-$11.00/kg for fresh fish, while 19% of respondents purchased fresh fish priced between $7.00-$9.00/kg (Figure 19).

Most respondents usually paid less than $7.00/kg for frozen fish, while 25% of respondents paid between $7.00-$9.00/kg (Figure 20).

QUESTION: How much do you usually pay for Fresh Fish?

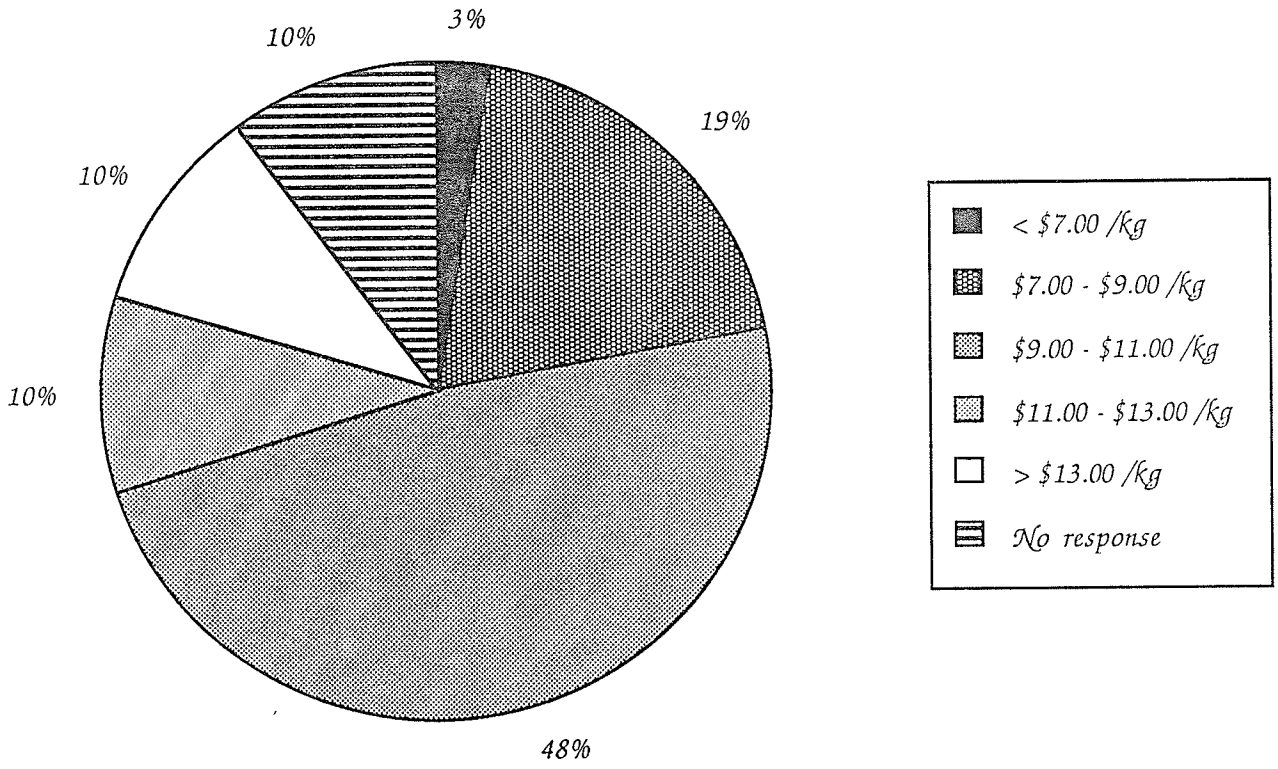


Figure 19: Consumer survey respondents' willingness to pay for fresh fish.

QUESTION: How much do you usually pay for Frozen Fish?

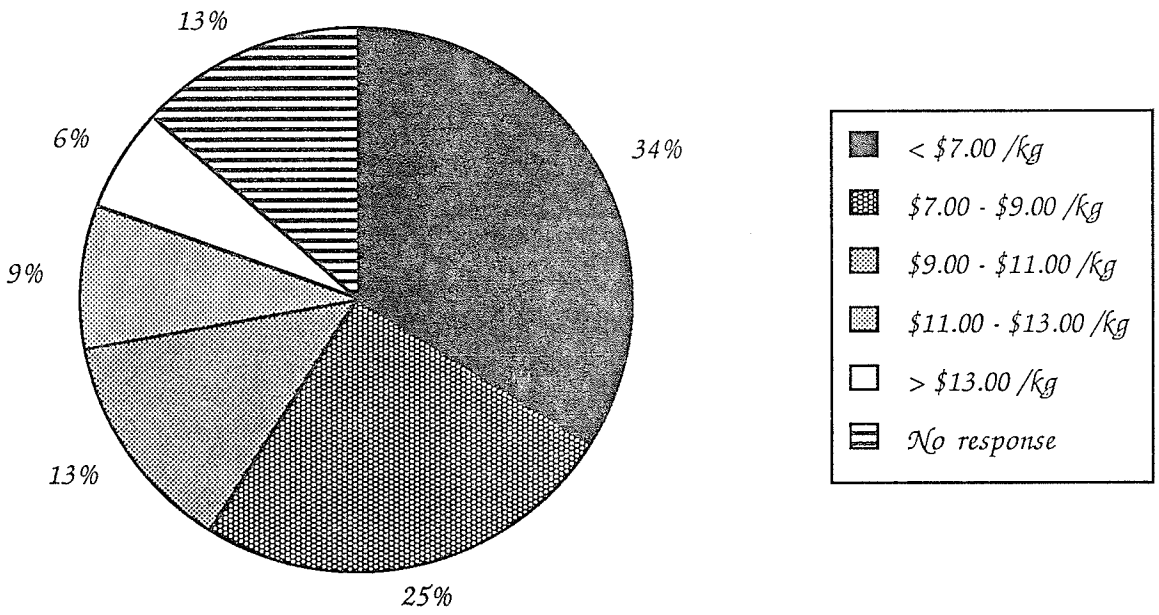


Figure 20: Consumer survey respondents' willingness to pay for frozen fish.

3.3.4 Product

Ninety-two percent of respondents purchased the cultured charr for regular family meals, while 8% purchased the charr for a special occasion (Figure 21).

The majority of respondents in the survey rated the size of the cultured charr satisfactory (Figure 22). Most of the respondents also rated the appearance, flavour, and texture of the charr as very appealing (64%, 79%, and 75% respectively) (Table 9). Raw flesh colour was rated as very appealing by half of the respondents and as moderately appealing by the other half (Table 9).

Twenty-six out of twenty-eight respondents would purchase the cultured Arctic charr again, but the majority would only purchase it once a month (Figure 23). Half of the respondents would purchase frozen cultured charr, while 39% would not. Thiry-one percent of respondents expected to pay between $7.00-$9.00/kg for frozen charr. Forty-two percent of the respondents did not answer this price question (Figure 24).

QUESTION: What was the Occasion for which the Charr were Purchased?

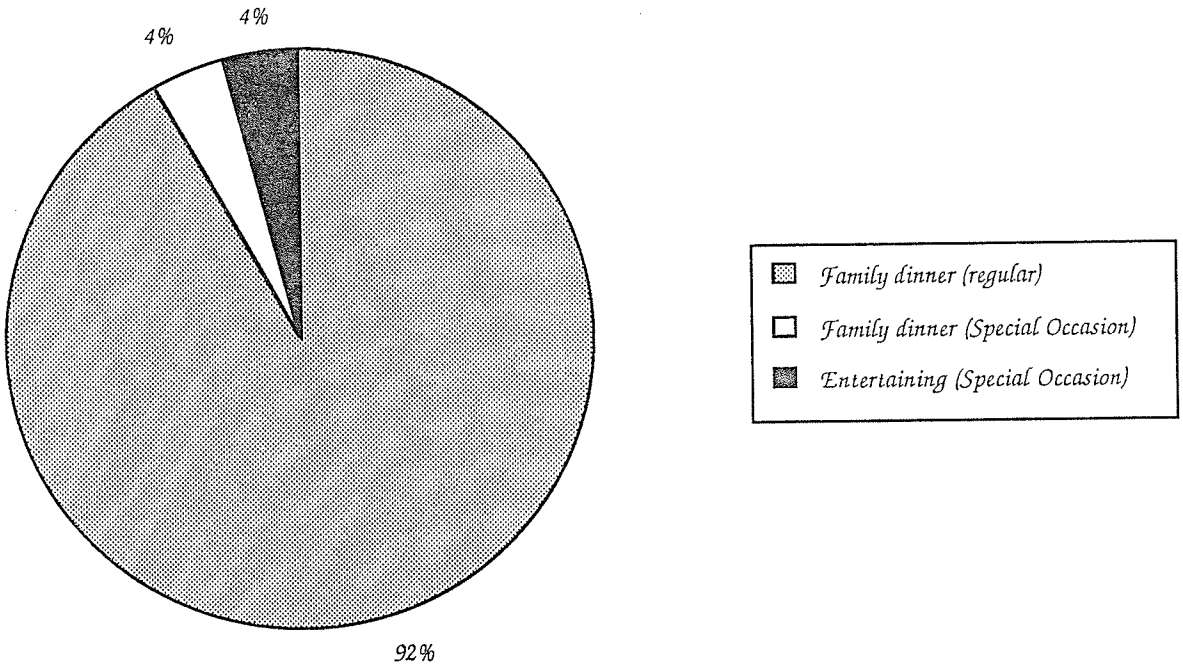


Figure 21: Lifestyle of consumer survey respondents.

QUESTION: Rate the Size of these Fish for Your Use :

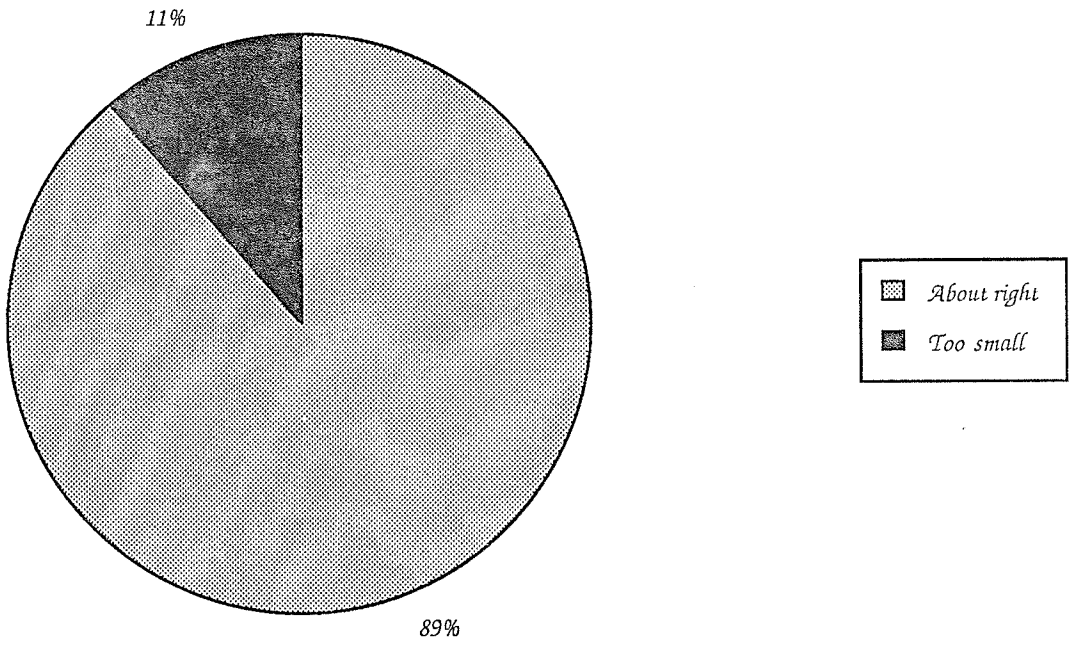


Figure 22: Preferences of consumer survey respondents to cultured charr.

TABLE 9

Consumer survey respondents rate the cultured charr product.

	Appearance	Raw Flesh Colour	Flavour	Texture
Very appealing	18	14	22	21
Moderately appealing	9	14	4	6
Unappealing	0	0	2	1
No response	1	0	0	0

Note: Data illustrated are the number of responses received.

QUESTION: How often would you Purchase This Product?

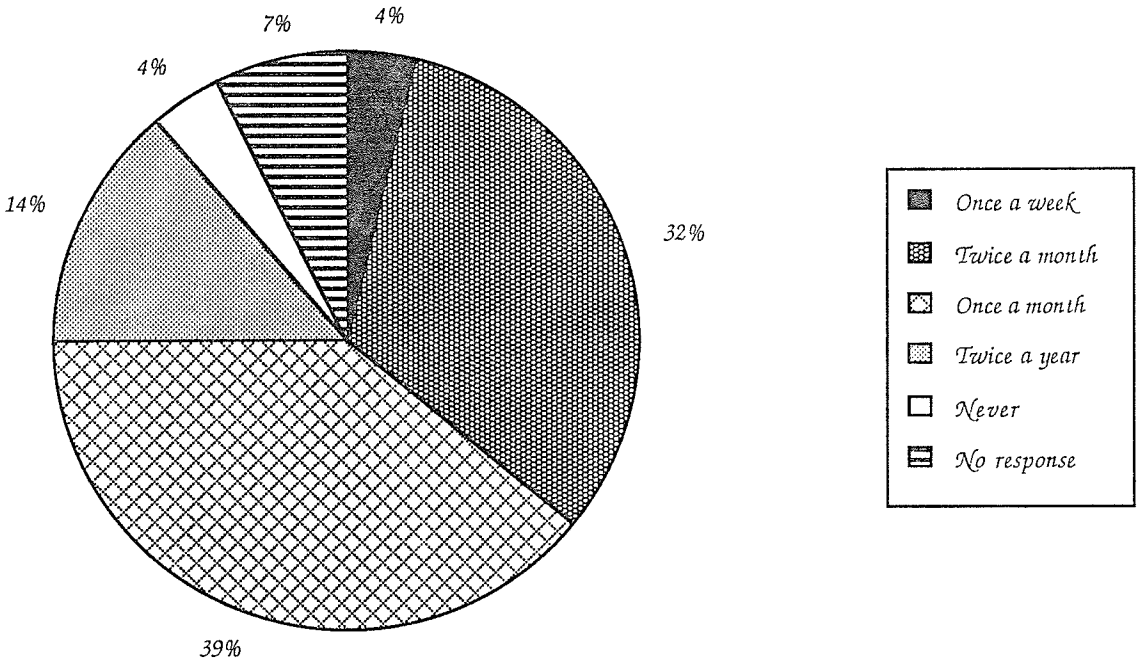


Figure 23: Shopping habits of survey respondents with respect to cultured Arctic charr.

QUESTION: What would you Expect to Spend on it as a Frozen Product?

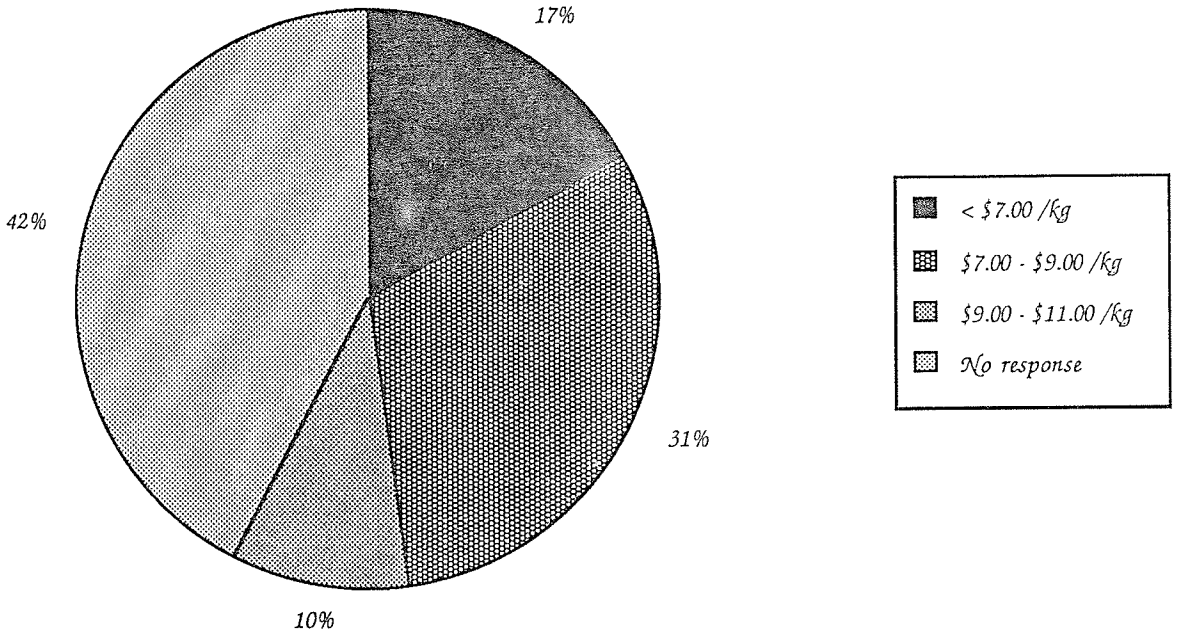


Figure 24: Consumer survey respondents' willingness to pay for frozen cultured charr.

3.3.5 Demographics

Three quarters of the respondents were Canadian citizens, and the remainder were from Hong Kong, Germany, Portugal, and the U.S.A. Thirty-two percent of respondents indicated that their cooking was influenced by cultural background. The influences originated in countries such as: China; Austria; Germany; Holland; Portugal; Britain and the U.S.S.R.

Eighty-two percent of respondents were between the ages of 36 and 65 (Figure 25).

QUESTION: What is Your Age?

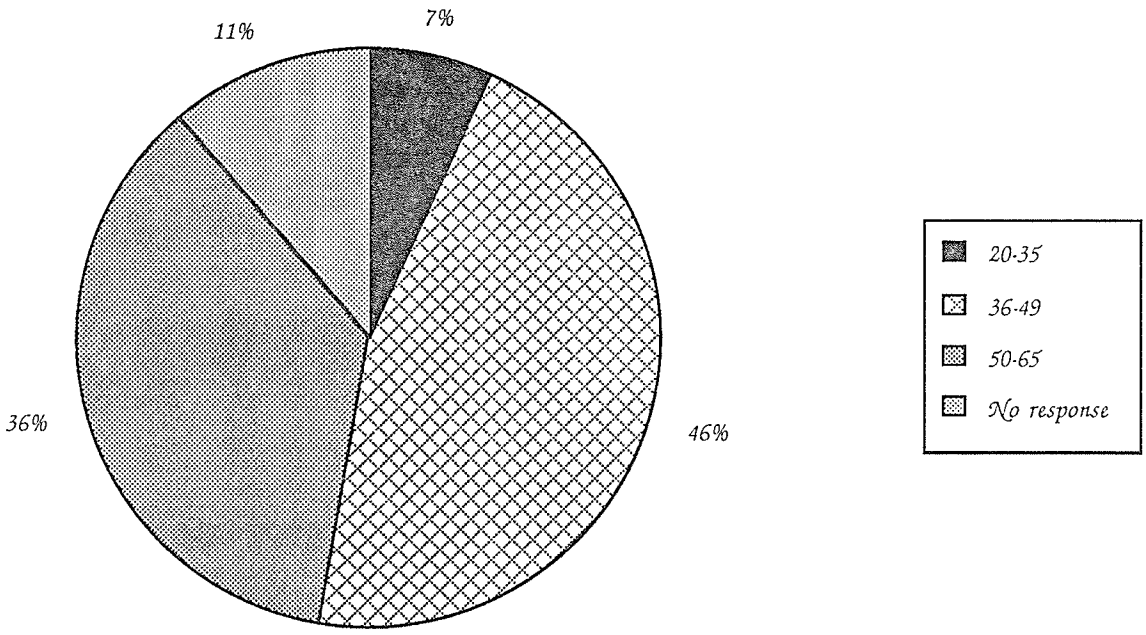


Figure 25: Age distribution of consumer survey respondents.

3.3.6 General Comments

In general, most respondents enjoyed the cultured Arctic charr and praised it for its "Canadian" flavour, texture and freshness. One respondent noted that cultured charr had more flavour than fresh salmon. While the majority of comments expressed enthusiasm for cultured charr, some of the more critical comments centered on presentation and price of the product. Some respondents disliked the slimeyness of the charr and others felt that cultured charr should have been price competitive with rainbow trout.

While discussing Arctic charr marketing, a Safeway buyer noted that frozen charr sell best during winter months when very few fresh fish are available in Winnipeg (R. Booth, pers. comm.). He also stated that frozen charr do not sell well when fresh charr are available. If fresh cultured Arctic charr were available commercially, Safeway indicated that it would purchase any amount produced for the summer barbeque season or the winter months.

Chapter IV

DISCUSSION

Arctic charr can be reared to market size (200-250 g) in less than 165 days (5.5 months) in an industrial waste heat system. Although the mean specific growth rate observed in Trial 1 (1.05%/day) was lower than the rate reported by Wandsvik and Jobling (1982), the mean specific growth rates of Trials 2 and 3 are comparable to the results of Swift (1964) and Papst and Hopky (1983). A high mean specific growth rate of 1.93%/day was observed when, given flow rate and water chemistry constraints, the highest number of fish tested in the existing system was 4000.

The size variation among charr observed in Trial 3 indicates a potential problem in Arctic charr aquaculture. The bimodal distribution of fish after 60 days into the production cycle demonstrates that a small percentage of charr (20% or less) remain stunted and will not reach market size within 165 days. Such size variation may be an inherent characteristic of the species (Papst and Hopky 1983), but if it could be reduced, then production levels would approach 100% instead of the current 80%. Nevertheless, an 80% production level for this system produces moderate returns.

The type of fish produced by this industrial waste heat system was low in contaminants. Results of the chemical analysis demonstrated that the pesticides, DDT and PCB, were both below human tolerance lev-

els of 5000 and 2000 ppb respectively. Metal levels in the cultured Arctic charr were typical of levels in fish from areas where there is no known external source of contamination. As with wild Arctic charr, the protein level in cultured charr was higher than in rainbow trout (M. Hendzel, pers. comm.).

Eight, dependent, biological operating criteria were identified for this system: water flow; temperature; loading rate; ammonia; nitrite; nitrate; pH and dissolved oxygen. Of these, the concentrations of ammonia and nitrite are the major limiting factors to the system. Water temperature was also somewhat limiting to the system when temperatures approached the upper tolerance limit (20 C) of Arctic charr.

When ammonia is produced in a culture system from feces and unused feed, a process termed denitrification occurs. It is caused by the build-up of ammonia and 2 naturally occurring species of bacteria:

ammonia + oxygen (toxic) —Nitrosomas sp.—> nitrite (toxic) + hydrogen + water

nitrite + oxygen —Nitrobacter sp.—> nitrate (nontoxic)

It is evident from water chemistry analysis that denitrification was proceeding to the point where the vat was acting as its own biological filter during growth trial 3 when fish density was maximum for the system. As the nitrate concentration increased, the concentrations of ammonia and nitrite were decreasing after having peaked 15-18 days into the production run. This result indicates that the second stage of denitrification had been induced by chemical conditions in the vat.

The economic ramifications of this phenomenon are important. If the vat can act as its own biological filter, then the design, manufacturing, and installment costs of biological filters need not be expended by Dominion Malting Ltd. This represents a capital investment saving of at least $50,000 (M.H. Papst, pers. comm.).

Results of water sampling conducted over 2 days during Trial 3 indicate that while the outflow siphon system was ineffective in removing accumulated wastes, the draw-down was effective in reducing ammonia and nitrite concentrations for short periods of time.

As the economic analysis demonstrates, a conservative 25% loss due to natural mortality and size inadequacies results in a substantial loss of revenue to the producer, but it does not make the venture any less feasible. A gross net return of $3,457 is generated on an estimated capital investment of $15,771. The speed at which capital investment is recovered by the company depends upon the structure of repayment. If vat replacement occurs every 10 years, then the company would probably opt to amortize the investment over a 10 year payback period and have an annual payment, or fixed cost, of $1,735. The company could also declare no dividend, or no net return, on each production cycle and repay capital investment within three and a half years, provided that the price received for cultured charr is not less than the break even price of $9.75/kg. If the producer price is less than $9.75/kg, then no gross net return would be generated. The enterprise, however, would remain viable because the annual fixed cost would still be paid. Producer prices greater than $9.75/kg would allow the company the option of repaying capital investment more quickly.

Economic returns from this aquaculture enterprise would be greater if its labour costs did not account for 57% of variable expenses. Waste heat aquaculture is labour intensive and a significant portion of variable expenses of any such system would be attributable to labour costs. In this case, however, the company adheres to its collective agreement and pays its workers $16.00-$16.50/hour. As a result, labour costs for this enterprise are approximately 7 times greater than those reported by commercial trout farms in Ontario (Jorgani et al. 1984).

It had been anticipated that feed and fingerling costs would be the major variable costs, but the economics of the system demonstrated otherwise. These costs, however, still represent two major variables in this enterprise. The cost of water discharge was also not as high as predicted by Dominion Malting Ltd., so an increased water flow could be used to offset any water chemistry problems without adversely affecting economic feasibility of the system.

Cultured Arctic charr had a good consumer acceptance , which reflected a high quality product. Respondents were pleased with the charr's size, appearance, flavour and texture. The white flesh colour of the cultured charr was rated moderately appealing by half of the respondents and as very appealing by the other half. Consumers indicated enthusiasm for the product since the majority of them would purchase cultured charr again if given the opportunity. Most respondents, however, preferred fresh fish and only half of the respondents would purchase cultured charr as a frozen product. Results indicate that consumers associate a higher degree of freshness with fresh fish than

with frozen fish. Among consumers surveyed, freshness is associated with quality.

Safeway's stated preference to purchase any quantity of fresh Arctic charr during the winter months complements the production system developed at Dominion Malting Ltd. If Arctic charr fingerlings were commercially available, they could only be purchased in September. A September stocking would result in a late January harvest.

Based on average household income data, the market for cultured Arctic charr appears to be comprised of affluent households. This was reflected in the percentages of surveys returned from the nine Safeway stores: 48% came from the Charleswood suburb, while only 6% came from the much less affluent core area of Winnipeg. The lower return of surveys from the core area did not indicate that sales of cultured charr were any less than in Charleswood. On the contrary, the fish counter manager at the Sargent and Maryland store reported that the charr were almost sold out within two days of receipt. Furthermore, he had priced the charr incorrectly at $18.00/kg. The cultured charr were supposed to be priced at $16.00/kg. The lower number of surveys returned from this area was probably a result of 2 factors: surveys may not have been distributed properly by Safeway personnel and the smaller response may reflect the large number of area residents for whom English is not their first language. Future consumer surveys may want to incorporate the use of personal interviews.

Most consumers have purchased fresh fish in the $9.00-$11.00/kg price range on a regular basis. For cultured Arctic charr, however,

the respondents paid $16.00/kg and indicated that they would purchase the product again if it became available. Most consumers would probably be willing to pay this price for fresh cultured charr, especially in the winter months. Safeway noted, however, that prices for cultured Arctic charr would decrease if the fish became available in medium quantities on a regular basis. Producers would receive rates comparable to what Safeway now pays for farmed salmon or rainbow trout ($4-$6/kg) (R. Booth, pers. comm.), and this decrease would presumably be passed on to consumers. Producers may want to consider maintaining exclusivity of the product to keep producer prices high.

Among consumers surveyed, development of a cultured Arctic charr industry based on a frozen product would be much less acceptable. While these consumers were willing to pay $7.00-$9.00/kg for frozen cultured charr, their preference was for fresh product and would expect to pay a higher price for the quality they associate with fresh fish.

Future studies having a government department and private industry as co-participants should have a formal agreement whereby the company provides equipment, fish, and feed, while the government provides research personnel. Such an agreement would provide an indication of both parties' committment to the research project. In my opinion, there exists in private industry, a fallacious, but commonly held belief that an object is without value until a price is attached to it. In this case, Dominion Malting Limited only installed a functioning low-water alarm after two fish kills and after learning that the company would be receiving $11.00/kg for any charr produced. The attitude

displayed toward the researcher and the study by company management and workers may have been responsible for the loss of 5,600 Arctic charr. It is, in part, due to the results of this study that the Department of Fisheries and Oceans now requires technology transfer agreements in all projects with private industry (M.H. Papst, pers. comm.).

Chapter V

CONCLUSIONS AND RECOMMENDATIONS

The commercial Arctic charr production system developed at the Dominion Malting plant is unique because:

1. it is located in Winnipeg, Manitoba and is, therefore, close to potentially large markets for cultured charr;

2. equipment utilized in malt production is adaptable to aquaculture, testifying to the similarities which exist between these two very different industries;

3. there is an abundant supply of heated well water produced for malting processes; and

4. the cost of water discharge resulted in the use of limited water flow, which contributed to the existence of water chemistry constraints on the production system when fish were stocked in it.

Results of the biological study, economic analysis of the enterprise, and consumer survey demonstrate the biological and economic feasibility of commercial Arctic charr production using this waste heat aquaculture system.

5.1 BIOLOGICAL CONCLUSIONS

An initial stocking level of 4000 25g Arctic charr fingerlings in the system requires 165 days to reach an average market size of 200-250g.

Of the eight, dependent, biological operating criteria identified for the system, ammonia and nitrite concentrations are the limiting factors which influenced fish growth. Alterations to water flow, water temperature, and feeding rates would minimize effects of these limiting factors.

Given the limits placed on the system by water quality and water flow, the highest number of Arctic charr fingerlings that can be stocked in the system is 4000.

A mean specific growth rate of 1.93%/day can be achieved when the maximum number of Arctic charr fingerlings are stocked in the system.

A quality fish is produced by this system. Levels of contaminants present in the cultured charr such as DDT, PCB and mercury are below human tolerance limits.

5.2 ECONOMIC CONCLUSIONS

Economic return on an estimated capital investment of $15,771 is $3,457. The investment can be recovered by the company within three and a half years if no dividend is declared and the price received for cultured charr is not less than $9.75/kg.

Among consumers surveyed, they were pleased with the size, appearance, flavour, and texture of cultured Arctic charr, but are divided in their opinion of the white flesh.

Among consumers surveyed, they preferred to purchase fresh fish.

The market for cultured charr encompassed most income levels and a variety of ethnic groups.

Cultured Arctic charr have a very good consumer acceptance in Winnipeg. Although only one retailer was used in the study, these fish appeared to have a good retailer acceptance.

5.3 RECOMMENDATIONS

I recommend to Dominion Malting Limited that the following strategies for future Arctic charr production be implemented.

1. A production cycle for this waste heat aquaculture system should incorporate the maximum stocking level of 4000 25g Arctic charr fingerlings per vat. This number of fish can be reared to market size (200-250g) in 165 days, provided that water temperatures are maintained at 15-16 C during the cycle.

2. Three measures should be taken to reduce the water chemistry problems associated with the maximum stocking level: increase water flow rate; remove the outflow siphon system from each vat; and increase the number of daily draw-downs from 2 to as many as 4.

3. When malt prices are low and vats are withdrawn from malt production, the company has the option of producing Arctic charr. It is, therefore, in the company's best interests to protect the current $11/kg price for their cultured Arctic charr by restricting quantities produced. (From an industry perspective, however, lower producer prices for cultured charr translate into a greater quantity of fish moved through markets, more jobs, etc.).

4. A production cycle for this system should incorporate a January harvest to capitalize on the high winter demand and/or reduced supply of fresh fish.

5. The company should maintain a fresh product line for local markets since consumers associate freshness with quality and, as a result, are willing to pay higher prices for fresh fish.

6. The company should develop export markets in Alberta, Ontario, U.S.A., and Europe to maximize profit for the waste heat aquaculture enterprise.

5.4 PERSPECTIVES

The waste heat aquaculture industry in Manitoba is in its infancy and, as is the case with any new industry, a cautious approach is required. Commercial production of Arctic charr is biologically and economically feasible, but care must be taken to preserve existing mar-

kets and to develop new ones. Quantity of fish produced is negatively correlated to price.

Further studies on waste heat aquaculture on Arctic charr are needed. Research into production curves would be valuable from a production economics perspective. Similarly, indepth research on the eight dependent biological operating criteria identified in this study and their effects on fish production would produce valuable information for future producers of Arctic charr.

The Freshwater Fish Marketing Corporation (FFMC) has a responsibility under its' mandate to market and trade in "fish, fish products, and fish by-products in and out of Canada", but it is evident that the corporation is not fulfilling this obligation. Through processing and marketing cultured Arctic charr, the FFMC would not only be fulfilling its' mandate, but more importantly, would provide an effective marketing and promotional impetus to the waste heat aquaculture industry in Manitoba.

LITERATURE CITED

Bardach, J.E., J.H. Ryther and W.O. McLarny. 1972. Aquaculture, the farming and husbandry of freshwater and marine organisms. Wiley-Interscience, New York, NY. 868p.

Blum, H. 1979. Trout farming in Ontario: an industry study. Ontario Ministry of Agriculture and Food, Economics Branch, Toronto. 25 p.

Bott, R. 1986. Net Profits, p. 20-27. IN Canadian Business Magazine. C.B. Media Ltd., Toronto. 59(2).

Gjedrem, T. and K. Gunnes. 1978. Comparison of growth rates in Atlantic salmon, Pink salmon, Arctic charr, Sea trout, and Rainbow trout under Norwegian fish farming conditions. Aquaculture. 13:135-141.

Hambrey, J. 1980. The importance of feeding, growth, and metabolism in a consideration of the economics of warm water fish culture using waste heat. Symposium on New Developments in the Utilization of Heated Effluents and of Recirculation Systems for Intensive Aquaculture, Stavanger, Norway. 17 p.

Jobling, M. 1983. Effect of feeding frequency on food intake and growth of Arctic charr, Salvelinus alpinus (L.). J. Fish. Biol. 23:177-185.

Jobling, M. and A. Wandsvik. 1983a. Effect of social interactions on growth rates and conversion efficiency of Arctic charr, Salvelinus alpinus L.. J. Fish. Biol. 22:577-584.

Jobling, M. and A. Wandsvik. 1983b. Quantitative protein requirements of Arctic charr, Salvelinus alpinus L.. J. Fish. Biol. 22:705-712.

Jorgani, H., W.C. Pfeiffer and R.V. Huntley. 1984. Major bioeconomic factors in producing rainbow trout commercially in Ontario: a multidisciplinary approach. University of Guelph, Guelph, Ontario. 51 p.

Kristofferson, A.H., D.K. McGowan and G.W. Carder. 1984. Management of the commercial fishery for anadromous Arctic charr in the Cambridge Bay area, Northwest Territories, Canada. IN L. Johnson and B. Burns [Eds.] Biology of the Arctic charr. Proceedings of the International Symposium on Arctic charr, Winnipeg, Manitoba, May 1981. University of Manitoba Press, Winnipeg. 584 p.

Meyer, F.P., J.W. Warren and T.G. Carey [Eds.]. 1983. A guide to integrated fish health management in the Great Lakes basin. Great Lakes Fishery Commission, Ann Arbor, Michigan. Spec. Pub. 83-2:272p.

Papst, M.H. and G.E.Hopky. 1982. Growth of rainbow trout (Salmo gairdneri Richardson) in a pilot commercial rearing system. Can. Tech. Rep. Fish. Aquat. Sci. 1112:iv + 18 p.

Papst, M.H. and G.E. Hopky. 1983. Growth of Arctic charr (Salvelinus alpinus L.) in a pilot commercial rearing system. Can. Tech. Rep Fish. Aquat. Sci. 1182:iv + 16 p.

Papst, M.H. and G.E. Hopky. 1984. Development of an Arctic charr (Salvelinus alpinus L.) brood stock. Aquaculture. 43:323-331.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 p.

Stainton, M.E., M.J. Capel and F.A.J. Armstrong. 1974. The chemical analysis of freshwater. Department of the Environment, Fisheries and Marine Science, Miscellaneous Publication No. 25, Winnipeg. 120 p.

Stankevicius, A.G. 1985. The policy implications of alternative fisheries management objectives in the Manitoba commercial fishing industry. M.N.R.M. Thesis, Univ. Manitoba. 129 p.

Swift, D.R. 1964. The effect of temperature and oxygen on the growth rate of the Windermere charr (Salvelinus alpinus Willughbii). Comp. Biochem. Physiol. 12:179-183.

Tabachek, J.L. 1984. Evaluation of grower diets for intensive culture of two strains of Arctic charr (Salvelinus alpinus). Can. Tech. Rep. Fish. Aquat. Sci. 1282:iv + 21 p.

Tennessee Valley Authority. 1977. State-of-the-art waste heat utilization for agriculture and aquaculture. The Tennessee Valley Authority and the Electric Power Institute, Technical Planning Studies. 405 p.

Uraiwan, S. 1982. The effect of genotype and environment on growth of rainbow trout (Salmo gairdneri Richardson). M.Sc. Thesis, Univ. Manitoba, Winnipeg, MB. 177 p.

Wandsvik, A. and M. Jobling. 1982. Observations on growth rates of Arctic charr, Salvelinus alpinus L., reared at low temperature. J. Fish. Biol. 20:689-699.

PERSONAL COMMUNICATIONS

Booth, R. Chief Meat and Fish Buyer, Canada Safeway Limited.

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Appendix A

CONSUMER SURVEY FOR CULTURED ARCTIC CHARR

THE UNIVERSITY OF MANITOBA NATURAL RESOURCES INSTITUTE Winnipeg, Manitoba Canada R3T 2N2 (204) 474-8375

MARKET STUDY SURVEY FOR ARCTIC CHARR

1. Including yourself, how many people are there in your household?

   Adults (18 or over) _____
   Teenagers (13 to 17) _____
   Children (12 and under) _____

2. What is the average annual income of your household?

   Less than $5,000 _____
   $5,000 - $15,000 _____
   $15,000 - $30,000 _____
   $30,000 - $45,000 _____
   More than $45,000 _____

3. Excluding milk, how often is grocery shopping done for your household?

   More than once a week _____
   Weekly _____
   Every two weeks _____
   Less often _____

4. Where do you usually grocery shop?

   Supermarket _____
   Small grocery store _____
   Smaller specialty shops _____

5. Where do you usually shop for fish?

   Supermarket _____
   Small grocery store _____
   Smaller specialty shops _____

6. How often do you purchase fresh fish?

   Once a week _____
   Twice a month _____
   Once a month _____
   Less than once a month _____

7. How much do you usually pay for fresh fish?

   Less than $7/Kg ($3/lb) _____
   $7-9/Kg ($3-4/lb) _____
   $9-11/Kg ($4-5/lb) _____
   $11-13/Kg ($5-6/lb) _____
   More than $13/Kg ($6/lb) _____

8. How often do you purchase frozen fish?

   Once a week _____
   Twice a month _____
   Once a month _____
   Less than once a month _____

9. How much do you usually pay for frozen fish?

   Less than $7/Kg ($3/lb) _____
   $7-9/Kg ($3-4/lb) _____
   $9-11/Kg ($4-5/lb) _____
   $11-13/Kg ($5-6/lb) _____
   More than $13/Kg ($6/lb) _____

10. How much do you normally spend on groceries in a week (food only)?

    Less than $25 _____
    $25-50 _____
    $50-75 _____
    $75-100 _____
    More than $100 _____

11. (a) In your household, who usually does the grocery shopping?

    You _____
    Your spouse _____
    You and your spouse _____
    Other (specify) _____

    (b) Who suggested that fish be placed on the grocery list for this shopping trip?

    You _____
    Your spouse _____
    You and your spouse _____
    Other (specify) _____

12. During the past month, have you personally eaten in a restaurant at which you paid, per person, for food and beverages:

    $50 or more? Yes_____ No_____
    $25 to $50? Yes_____ No_____
    $10 to $25? Yes_____ No_____
    $5 to $10? Yes_____ No_____
    Less than $5 (fast food) Yes_____ No_____

13. How often do you entertain in your home?

    More than once a week _____
    Once a week _____
    Twice a month _____
    Once a month _____
    Less than once a month _____

14. Do you serve fish products when entertaining?

Yes_____ No_____

15. Check off the items that you have purchased in the past year:

PRODUCT	FRESH	SMOKED	FROZEN	CANNED
Whitefish				
Salmon				
Tuna				
Mackerel				
Rainbow trout				
Arctic charr (not introductory product)				
Goldeye				
Tullibee				
Northern Pike				
Pickerel				
Cod				
Perch				
Catfish				
Red Snapper				
Lingcod				
Frog's legs				
Mussels				
Oysters				
Clams				
Lobster				
Crab				
Scallops				
Shrimp				
Squid				

16. Have you purchased fresh Rainbow trout?

Yes_____ No_____

17. Have you purchased frozen Rainbow trout?

Yes_____ No_____

18. If you have purchased frozen Rainbow trout, did it originate from:

U.S.A. _____
Japan _____
Local (farmed trout) _____
Other (specify) _____
Do not know _____

19. Questions in the following section refer to the introductory product that you purchased at SAFEWAY.

(a) How many Arctic charr did you purchase? _____

(b) Were the charr you purchased fresh or frozen? _____

(c) How soon after purchasing the charr did you use them?

Same day _____
1 day later _____
2 days later _____
3 days later _____
4 or more days later _____
Product frozen for later use _____

(d) What was the occasion for which the charr was purchased?

Family dinner (regular meal) _____
Special occasion: family _____
entertaining _____
Other (specify) _____

(e) Rate the size of these fish for your use:

Too large _____
About right _____
Too small _____

(f) How would you describe the appearance of these fish?

Very appealing _____
Moderately appealing _____
Unappealing _____

Why? _____

(g) How would you describe the raw flesh colour of these fish?

Very appealing _____
Moderately appealing _____
Unappealing _____

Why? _____

(h) How would you describe the flavour of these fish?

Very appealing _____
Moderately appealing _____
Unappealing _____

Why? _____

(i) How would you describe the texture of these fish?

Very appealing _____
Moderately appealing _____
Unappealing _____

Why? _____

(j) Would you purchase this product again?

Yes_____ No_____

(k) How often would you purchase this product?

Once a week _____
Twice a month _____
Once a month _____
Twice a year _____
Never _____

(l) How often would you use this product?

Once a week _____
Twice a month _____
Once a month _____
Twice a year _____
Never _____

(m) How did you prepare this product?

baked _____
broiled _____
barbequed _____
pan-fried _____
deep-fried _____
stir-fried _____
poached _____
steamed _____
microwave cooked _____
other (specify) _____

(n) Would you purchase this fish as a frozen product?

Yes_____ No_____

(o) If yes, what would you expect to spend on it as a frozen product?

Less than $7/Kg ($3/lb) _____
$7-9/Kg ($3-4/lb) _____
$9-11/Kg ($4-5/lb) _____
$11-13/Kg ($5-6/lb) _____
More than $13/Kg ($6/lb) _____

(p) What is the main reason for your purchase of this product?

Nutritional value _____
Freshness _____

(p) cont'd

Advertising: word of mouth _____ media _____
Novelty of being able to purchase Arctic charr _____
Reputation of the name "Arctic charr" _____
Other (specify) _____

Please use this space to make any other comments about this product:

20. How long have you lived in Manitoba?

Less than 1 year _____
1 to 5 years _____
6 to 20 years _____
More than 20 years _____

21. Were you born in Canada? Yes_____ No_____

If no, in what country were you born? _____

22. If yes, when did your ancestors come to Canada?

	Mother's side	Father's side
Within the last 10 years	_____	_____
10 to 25 years ago	_____	_____
25 to 50 years ago	_____	_____
50 to 75 years ago	_____	_____
75 to 100 years ago	_____	_____
More than 100 years ago	_____	_____

23. If you are married, was your spouse born in Canada? Yes_____ No_____

If no, in what country was he/she born? _____

24. If yes, when did your spouse's ancestors come to Canada?

	Mother's side	Father's side
Within the last 10 years	_____	_____
10 to 25 years ago	_____	_____
25 to 50 years ago	_____	_____
50 to 75 years ago	_____	_____
75 to 100 years ago	_____	_____
More than 100 years ago	_____	_____

25. Does your cooking have an ethnic influence that was passed on to you by your ancestors or your spouse's ancestors?

Yes_____ No_____

26. If so, from what country or cultural background does this influence originate? _____

27. What is your age?

Under 20	_____
20 to 35	_____
36 to 49	_____
50 to 65	_____
Over 65	_____

28. Are you: Male_____ Female_____

If you have any questions regarding this survey, please contact Ms. B. Hathaway (474-8373), Natural Resources Institute, University of Manitoba, Winnipeg, Manitoba, R3T 2N2.

Appendix B

RESULTS OF CULTURED CHARR ANALYSIS

Government of Canada / Gouvernement du Canada

MEMORANDUM **NOTE DE SERVICE**

TO: Bev Hathaway,
and Mike Papst
Resource Development Research

November 10, 1986

File: 020-1

FROM: Marilyn Hendzel
Regional Chemist
Inspection, Central & Arctic Region
Department of Fisheries & Oceans
501 University Crescent
WINNIPEG, Manitoba. R3T 2N6

Subject: **Analysis of Arctic Char**
Objet:

Attached is a summary of results of analyses conducted on arctic char samples submitted in early September.

None of the contaminant levels are considered significant from a human health perspective. Measured levels of DDT and PCB are both well below the tolerances of 5000 and 2000 ppb respectively. Metal levels are typical of levels in fish from areas where there is no known external source of contaminantion. Mercury is well below the tolerance of 0.5 ppm.

If you have any questions regarding the data or require further information, please contact me.

Marilyn Hendzel

Att.

TS50:ARCHAR.020

Chemical Analysis of Char Samples, Dominion Malting

	Sample A	Sample B	Sample C
Weight (g)	202	244	346
Length (mm)	280	280	320

I Pesticide Results (ppb)

Hexachlorobenzene	1	1	1
DDT and metabolites	12<13	10<11	6<8
PCB	60	41	49

No other pesticides included in our normal scan were identified (less than detection limit levels, that is, 1 ppb).

These pesticides are:
- α and γ hexachlorocyclohexane
- heptachlor
- heptachlor epoxide
- aldrin
- dieldrin
- endrin
- methoxychlor

II Metals (ppm)

Mercury	0.03	0.03	0.03
Lead	<0.01	0.01	<0.01
Copper	1.05	0.56	0.57
Cadmium	0.01	<0.01	<0.01
Zinc	4.22	3.79	3.87

III Proximate Composition (wt %)

Lipid	2.77	2.85	3.47
Protein	21.0	21.2	21.1
Moisture	74.0	73.8	73.0
Ash	1.50	1.35	1.49

Note: All results are based on wet weight.

TS50:ARCHAR.020

Appendix C

ECONOMIC DATA AND CALCULATIONS

I. REVENUE

Assuming a 25% total fish loss due to mortality (5%) and inadequate harvest size (20%), there will be 3000/4000 marketable Arctic charr (200-250 g) in each vat. Using the average harvest size (225 g), revenue from fresh fish sales is calculated by:

3000 fish x 0.225 kg/fish x $11.03/kg = $7,445.25

4 x $7,445.25 = $29,781.00

II. EXPENSE DATA

1. Variable Costs

(a) Fingerlings: G + S Farms in LaBroquerie, Manitoba could supply 4" Arctic charr fingerlings for $0.20 each on an annual basis (September) if charr eggs were commercially available. The delivery charge was quoted to be $1.00/km. No quantity limits were given.

16,000 fingerlings x $0.20 each	=	$3,200.00
100 km to Winnipeg	=	$ 100.00
		$3,300.00

The waste heat aquaculture system requires 3" . fingerlings, so cost is estimated at $3,200.

(b) Feed: Rainbow trout feed produced by Martins Feed Mills in Elmira, Ontario was used in this study. Feed size used ranged from 2GR to 5PT. This feed is available year round and there is a bulk discount of $35/tonne offered.

Cost of feed/kg is as follows:

$0.60/kg feed
$0.44/kg transport from Elmira
$1.04.kg TOTAL COST

The 4 vat system would require a total of 3810.72 kilograms of feed for one production cycle lasting 165 days (see table below).

3810.72 kg x $1.04/kg = $ 3,963.15
- 105.00 discount
$ 3,858.15

DAY	MEAN WEIGHT (g)	FEED/DAY (kg)	TOTAL FEED (g)
0	32.6	12.00	-
22	43.2	11.36	264.00
33 (11)	50.1	17.28	124.96
48 (15)	63.3	18.56	259.20
62 (14)	80.2	23.52	259.84
85 (23)	85.0	24.80	540.96
100 (15)	107.3	27.68	372.00
115 (15)	97.9	26.88	415.20
129 (14)	134.8	34.72	376.32
148 (19)	141.4	31.68	659.68
165 (17)	164.9	-	538.56
		HARVEST	3810.72

Note: Table is based on growth data from Trial 1, but using 16,000 charr at 100% feed ration.

(c) Labour:

Aquaculturist

feeding, water sampling, draw-downs = 117.5 hrs
fish weight census = 23.5 hrs
coordination, analysis,etc = 117.5 hrs
285 hrs

258.5 hrs x 4 = 1034 hrs total
1034 hrs x $12.08/hr = $12,500.00

General Unionized

Used for a 4-day harvest of the entire system. Total cost is: 32 hrs x 3 workers x $16/hr, or $1,536.00.

(d) Water Quality: The testing fee charged by the DFO chemistry lab is $1.30 per contaminant tested. Assuming that water is tested each week from 1 vat only for ammonia, nitrite, nitrate, and pH, the total cost would be:

4 x $1.30 = $5.20/week x 23.5 weeks = $119.60

(e) Discharge:

For a 23.5 week production cycle, the total water discharged would be (per vat):

6250 gal (initial fill) + 77,740 gal for 31 days
Only 32% of water used is heated.

$$\frac{77{,}740 \text{ gal}}{x \text{ gal}} = \frac{31 \text{ days}}{165 \text{ days}} = 413{,}777 \text{ gallons}$$

413,777 gal + 6250 gal = 420,027 gal used
0.32(413,777) = 132,409 gallons heated

Cost of Discharge:

420,027 gal/cycle/vat x 4 vats = 1,680,108 gallons/cycle

Sewer cost is $0.94/100 cubic feet
1 gallon = 0.16 cu ft.
1 cu ft. = 6.25 gallons

1,608,108 gal(0.16 cu ft./gal) = 268,817.28 cu ft.

268,817.28 cu ft./100 = 2688.17
2688.17 x $0.94 = $2,526.88

Heating Cost:

132,409 gal/cycle/vat(4) = 529,636 gal/cycle are heated.

Gas is used to heat the water and costs $3.60 per 1000 cu ft.
1 cu ft. = 100,000 B.T.U.'s
$3.60 per 100,000,000 B.T.U.'s

1 B.T.U. is needed to raise 1 lb of water 1 degree Fahrenheit and 1 gallon equals 10 lbs. Thus, 10 B.T.U./gal are needed to raise 1 gal of water 1 degree F. Water comes in from the well at 40 degrees F and is heated to 46-55 degrees F on average.
At upper limit, water is heated 15 degrees:

529,636 gal(10 B.T.U./gal)(15) = 79,445,400 B.T.U.'s/cycle

79,445,400/100,000,000 = 0.79

0.79 x $3.60 = $2.84

(f) Processing: Manitoba Cold storage charges $7.50/100 lbs of fish cleaned:

12,000 charr x 0.225 kg = 2700 kg = 5,947 lbs

Cleaning is $0.04/fish x 12,000	$ 480.00
Packaging is $3.45/100 lbs	205.28
TOTAL	$ 685.28

If boxes are supplied by producer, then broker will pick up fish at MB Cold Storage.

2. Capital Investment

(a) Vat Conversion: Cost of renovation materials/vat is $179.14.

For 4 vats the cost is $719.94. Labour for the conversion of 1 vat is 46 hrs x $16.50/hr and for the 4 vats the total wages would be $3,306.

(b) Water Quality: Basic lab equipment used in water sampling and analysis is estimated to cost $250.

(c) Harvest: The following equipment is required:

1 used half ton truck	$7,000.00
2 hand nets, garbage pails	100.00
1 ice machine	1,000.00
30 fish bins	706.20
240 cardboard fish boxes	2,160.00
TOTAL (incl. tax)	$10,966.00

(d) Fixed Cost: Malting vats (ie. steep tanks) have an average "lifespan" of 25-50 years, but for purposes of this analysis, it has been set at 10 years.

Annual fixed cost is calculated by:

$$\frac{\text{Capital investment}}{\text{10 years}} = \$1,577.10$$

Assuming a 10% interest rate,
0.10 x $1,577.10 = $157.71

$1,577.10 + $157.71 = $1,734.81 = $1,735

Appendix D

CONSUMER SURVEY RESULTS BY DIVISION

CONSUMER SURVEY RESULTS: SOUTHERN DIVISION (N=28)

1. Including yourself, how many people are there in your household?

Adults (18 or over)
Teenagers (13 to 17)
Children (12 and under)

Households with children 8
Households without children 20

2. What is the average annual income of your household?

Less than $5,000	0
$5,000 - $15,000	2
$15,000 - $30,000	1
$30,000 - $45,000	6
More than $45,000	14
NO RESPONSE	5

3. Excluding milk, how often is grocery shopping done for your household?

More than once a week	13
Weekly	11
Every two weeks	4
Less often	0
NO RESPONSE	1

4. Where do you usually grocery shop?

Supermarket	27
Small grocery store	1
Smaller specialty shops	0
NO RESPONSE	1

5. Where do you usually shop for fish?

Supermarket	27
Small grocery store	0
Smaller specialty shops	3
NO RESONSE	1

6. How often do you purchase <u>fresh</u> fish?

Once a week	16
Twice a month	4
Once a month	3
Less than once a month	4
NO RESPONSE	1

7. How much do you usually pay for <u>fresh</u> fish?

Less than $7/Kg ($3/lb)	1
$7-9/Kg ($3-4/lb)	6
$9-11/Kg ($4-5/lb)	15
$11-13/Kg ($5-6/lb)	3
More than $13/Kg ($6/lb)	3
NO RESPONSE	3

8. How often do you purchase frozen fish?

Once a week	5
Twice a month	5
Once a month	4
Less than once a month	13
NO RESPONSE	1

9. How much do you usually pay for frozen fish?

Less than $7/Kg ($3/lb)	11
$7-9/Kg ($3-4/lb)	8
$9-11/Kg ($4-5/lb)	4
$11-13/Kg ($5-6/lb)	3
More than $13/Kg ($6/lb)	2
NO RESPONSE	4

10. How much do you normally spend on groceries in a week (food only)?

Less than $25	0
$25-50	3
$50-75	8
$75-100	9
More than $100	6
NO RESPONSE	2

11. (a) In your household, who usually does the grocery shopping?

You	13
Your spouse	3
You and your spouse	11
Other	0
NO RESPONSE	1

(b) Who suggested that fish be placed on the grocery list for this shopping trip?

You	12
Your spouse	4
You and your spouse	11
Other	1
NO RESPONSE	1

12. During the past month, have you personally eaten in a restaurant at which you paid, per person, for food and beverages:

$50 or more?	Yes 3	No 12	N.R. 13
$25 to $50?	Yes 5	No 8	N.R. 15
$10 to $25?	Yes 19	No 2	N.R. 7
$5 to $10?	Yes 13	No 4	N.R. 11
Less than $5?	Yes 12	No 0	N.R. 16

13. How often do you entertain in your home?

More than once a week	1
Once a week	3
Twice a month	8
Once a month	4
Less than once a month	11
NO RESPONSE	1

14. Do you serve fish products when entertaining?

Yes 18 No 8 N.R. 2

15. Check off the items that you have purchased in the past year:

PRODUCT	FRESH	SMOKED	FROZEN	CANNED
Whitefish	13			
Salmon	24	6	6	15
Tuna	2			20
Mackerel	1			
Rainbow trout	12		4	1
Arctic charr (not introductory product)	10		2	
Goldeye	5	9		
Tullibee	0	1		
Northern Pike	3			
Pickerel	15		9	
Cod	6		6	
Perch	5			
Catfish	1			
Red Snapper	12			
Lingcod	1			
Frog's legs			1	0
Mussels	7	1		1
Oysters	12		0	5
Clams	7			4
Lobster	11			
Crab	6		2	8
Scallops	12		6	
Shrimp	19		11	12
Squid	4			0

16. Have you purchased fresh Rainbow trout?

Yes 16 No 11 N.R. 1

17. Have you purchased frozen Rainbow trout?

Yes 11 No 16 N.R. 1

18. If you have purchased frozen Rainbow trout, did it originate from:

U.S.A.	1
Japan	1
Local (farmed trout)	2
Other	0
Do not know	11
NO RESPONSE	15

19. Questions in the following section refer to the introductory product that you purchased at SAFEWAY.

(a) How many Arctic charr did you purchase? 2.82 (avg.)

(b) Were the charr fresh or frozen? all fresh

(c) How soon after purchasing the charr did you use them?

Same day	12
1 day later	10
2 days later	3
3 days later	2
4 or more days later	0
Product frozen for later use	2

(d) What was the occasion for which the charr was purchased?

Family dinner (regular meal)	26
Special occasion: family	1
entertaining	1
Other	0

(e) Rate the size of these fish for your use:

Too large	0
About right	25
Too small	3

(f) How would you describe the appearance of these fish?

Very appealing	18
Moderately appealing	9
Unappealing	0
NO RESPONSE	1

(g) How would you describe the raw flesh clour of these fish?

Very appealing	14
Moderately appealing	14
Unappealing	0

(h) How would you describe the flavour of these fish?

Very appealing	22
Moderately appealing	4
Unappealing	2

(i) How would you describe the texture of these fish?

Very appealing	21
Moderately appealing	6
Unappealing	1

(j) Would you purchase this product again?

Yes 26 No 2

(k) How often would you purchase this product?

Once a week	1
Twice a month	9
Once a month	11
Twice a year	4
Never	1
NO RESPONSE	2

(l) How often would you use this product?

Once a week	2
Twice a month	10
Once a month	9
Twice a year	5
Never	1
NO RESPONSE	1

(m) How did you prepare this product?

baked	13
broiled	3
barbequed	1
pan-fried	7
deep-fried	0
stir-fried	0
poached	0
steamed	2
microwave cooked	2
other	0

(n) Would you purchase this fish as a <u>frozen</u> product?

Yes 14 No 11 N.R. 3

(o) If yes, what would you expect to spend on it as a <u>frozen</u> product?

Less than $7/Kg ($3/lb)	5
$7-9/Kg ($3-4/lb)	9
$9-11/Kg ($4-5/lb)	3
$11-13/Kg ($5-6/lb)	0
More than $13/Kg ($6/lb)	0
NO RESPONSE	12

(p) What is the main reson for your purchase of this product?

Nutritional value	10
Freshness	15
Advertising: word of mouth	7
media	0
Novelty of being able to purchase Arctic charr	5
Reputation of name "Arctic charr"	5
Other	6

20. How long have you lived in Manitoba?

Less than 1 year	3
1 to 5 years	0
6 to 20 years	6
More than 20 years	18
NO RESPONSE	1

21. Were you born in Canada?

Yes 26 No 1 N.R. 1

23. If you are married, was your spouse born in Canada?

Yes 19 No 7 N.R. 2

25. Does your cooking have an ethnic influence that was passed on to you by your ancestors or your spouse's ancestors?

Yes 9 No 17 N.R. 2

27. What is your age?

Under 20	0
20 to 35	2
36 to 49	13
50 to 65	10
Over 65	0
NO RESPONSE	3

28. Are you: Male 10 Female 15 N.R. 3

CONSUMER SURVEY RESULTS: NORTHERN DIVISION (N=5)

1. Including yourself, how many people are there in your household?

Adults (18 or over)	
Teenagers (13 to 17)	
Children (12 and under)	

Households with children	1
Households without children	4

2. What is the average annual income of your household?

Less than $5,000	0
$5,000 - $15,000	0
$15,000 - $30,000	1
$30,000 - $45,000	2
More than $45,000	2

3. Excluding milk, how often is grocery shopping done for your household

More than once a week	2
Weekly	2
Every two weeks	1
Less often	0

4. Where do you usually grocery shop?

Supermarket	4
Small grocery store	1
Smaller specialty shops	1

5. Where do you usually shop for fish?

Supermarket	5
Small grocery store	0
Smaller specialty shops	1

6. How often do you purchase fresh fish?

Once a week	2
Twice a month	2
Once a month	0
Less than once a month	1

7. How much do you usually pay for fresh fish?

Less than $7/Kg ($3/lb)	0
$7-9/Kg ($3-4/lb)	3
$9-11/Kg ($4-5/lb)	2
$11-13/Kg ($5-6/lb)	0
More than $13/Kg ($6/lb)	0

8. How often do you purchase frozen fish?

Once a week	1
Twice a month	0
Once a month	1
Less than once a month	2
NO RESPONSE	1

9. How much do you usually pay for frozen fish?

Less than $7/Kg ($3/lb)	1
$7-9/Kg ($3-4/lb)	3
$9-11/Kg ($4-5/lb)	0
$11-13/Kg ($5-6/lb)	0
More than $13/Kg ($6/lb)	0
NO RESPONSE	1

10. How much do you normally spend on groceries in a week (food only)?

Less than $25	0
$25-50	1
$50-75	4
$75-100	0
More than $100	0

11. (a) In your household, who usually does the grocery shopping?

You	4
Your spouse	0
You and your spouse	1
Other	1

(b) Who suggested that fish be placed on the grocery list for this shopping trip?

You	3
Your spouse	1
You and your spouse	0
Other	1

12. During the past month, have you personally eaten in a restaurant at which you paid, per person, for food and beverages:

$50 or more?	Yes 1	No 2	N.R. 2
$25 to $50?	Yes 3	No 1	N.R. 1
$10 to $25?	Yes 3	No 0	N.R. 2
$5 to $10?	Yes 3	No 0	N.R. 2
Less than $5?	Yes 4	No 0	N.R. 1

13. How often do you entertain in your home?

More than once a week	0
Once a week	2
Twice a month	0
Once a month	1
Less than once a month	2

14. Do you serve fish products when entertaining?

Yes 3 No 1 N.R. 1

15. Check off the items that you have purchased in the past year:

PRODUCT	FRESH	SMOKED	FROZEN	CANNED
Whitefish	1			
Salmon	5	2	3	5
Tuna	0			4
Mackerel	0			
Rainbow trout	4		0	0
Arctic charr (not introductory product)	1		1	
Goldeye	1	1		
Tullibee	1	0		
Northern Pike	1			
Pickerel	4		2	
Cod	3		3	
Perch	0			
Catfish	2			
Red Snapper	0			
Lingcod	0			
Frog's legs			0	0
Mussels	0	0		0
Oysters	0		0	2
Clams	0			2
Lobster	1			
Crab	2		0	1
Scallops	3		0	
Shrimp	4		3	3
Squid	0			0

16. Have you purchased fresh Rainbow trout?

Yes 4 No 1

17. Have you purchased frozen Rainbow trout?

Yes 2 No 3

18. If you have purchased frozen Rainbow trout, did it originate from:

U.S.A.	0
Japan	0
Local (farmed trout)	0
Other	0
Do not know	2
NO RESPONSE	3

19. Questions in the following section refer to the introductory product that you purchased at SAFEWAY.

(a) How many Arctic charr did you purchase? 2.00 (avg.)

(b) Were the charr fresh or frozen? all fresh

(c) How soon after purchasing the charr did you use them?

Same day	2
1 day later	2
2 days later	1
3 days later	0
4 or more days later	0
Product frozen for later use	0

(d) What was the occasion for which the charr was purchased?

Family dinner (regular meal)	4
Special occasion: family	0
entertaining	1
Other	0

(e) Rate the size of these fish for your use:

Too large	0
About right	4
Too small	2

(f) How would you describe the appearance of these fish?

Very appealing	2
Moderately appealing	3
Unappealing	1

(g) How would you describe the raw flesh color of these fish?

Very appealing	3
Moderately appealing	2
Unappealing	1

(h) How would you describe the flavour of these fish?

Very appealing	5
Moderately appealing	1
Unappealing	0

(i) How would you describe the texture of these fish?

Very appealing	4
Moderately appealing	0
Unappealing	0

(j) Would you purchase this product again?

Yes 5 No 0

(k) How often would you purchase this product?

Once a week	1
Twice a month	1
Once a month	2
Twice a year	1
Never	0

(l) How often would you use this product?

Once a week	1
Twice a month	1
Once a month	2
Twice a year	1
Never	0

(m) How did you prepare this product?

baked	1
broiled	2
barbequed	0
pan-fried	2
deep-fried	0
stir-fried	0
poached	0
steamed	0
microwave cooked	0
other	0

(n) Would you purchase this fish as a <u>frozen</u> product?

Yes 1 No 3 N.R. 1

(o) If yes, what would you expect to spend on it as a <u>frozen</u> product?

Less than $7/Kg ($3/lb)	2
$7-9/Kg ($3-4/lb)	1
$9-11/Kg ($4-5/lb)	0
$11-13/Kg ($5-6/lb)	0
More than $13/Kg ($6/lb)	0
NO RESPONSE	3

(p) What is the main reson for your purchase of this product?

Nutritional value	1
Freshness	3
Advertising: word of mouth 0	media 0
Novelty of being able to purchase Arctic charr	2
Reputation of name "Arctic charr"	3
Other	0

20. How long have you lived in Manitoba?

Less than 1 year	0
1 to 5 years	1
6 to 20 years	2
More than 20 years	2

21. Were you born in Canada?

Yes 5 No 0

23. If you are married, was your spouse born in Canada?

Yes 3 No 0 N.R. 2

25. Does your cooking have an ethnic influence that was passed on to you by your ancestors or your spouse's ancestors?

Yes 2 No 3

27. What is your age?

Under 20	0
20 to 35	1
36 to 49	2
50 to 65	2
Over 65	0

28. Are you: Male 2 Female 3