GASTRIC EVACUATION RATES IN RAINBOW TROUT (*Oncorhynchus mykiss*) FED DIFFERENT DIETS

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ABSTRACT

The passage time of ingested food through the digestive tract affects the appropriate timing of meals and the amount of feed that can be consumed. The rate of digestion of dietary components and the efficiency with which nutrients are absorbed may also be affected by passage time. The present study examined the effects of different dietary concentrations of fibre, lipid and gelatin on the rate of food passage in rainbow trout reared in fresh and salt water.

Different ingredients were added to diets in two separate experiments. Feed conversion rates for these diets were determined. The effect of these ingredients on the rate of passage was determined through timed dissections of the stomach and intestine of rainbow trout. The contents were weighed and, in experiment 2, the water content determined.

In experiment 1, feeding trials involving three experimental diets and one control diet were conducted. The control diet contained 8% lipid and no fibre additions. The experimental diets were: a 20% lipid diet, 12% pectin diet and a 12% cellulose diet. The pectin diet resulted in poor feed consumption and growth, indicating that an attribute of the diet, taste or texture, was disliked by the fish. The high lipid diet had the best feed conversion while the diet containing cellulose resulted in poor feed conversion.

In Experiment 2, both a fresh water and a salt water location

were used. Four different dietary treatments were imposed on fish in the fresh water location: a basal diet (control); the basal diet containing 10% gelatin; the basal diet containing an additional %10 of oil; and, a basal diet containing 10% cellulose and an additional 8% of oil. At the salt water location, diets were similar except the omission of the diet containing gelatin. The effects of the dietary additions on the movement of ingesta through the stomach and intestine were determined for each diet at each site. The percentages of water in the ingesta in the stomachs were compared to determine if there were differences when fish are grown in a saltwater environment as compared to when they are grown in a freshwater environment.

In both experiment 1 and experiment 2, the addition of cellulose to the basal diet, (Diet 4) increased the rate of passage during the initial 12 hours after feeding. Consumption of the diet containing cellose was greater than that of the other experimental diets. An increased consumption of diets with a cellulose addition concurs with the findings reported in the literature. The increased evacuation rate, however, is contrary to previous findings. The high lipid diets evacuated slowly for the first 6 hours and then rapidly after that time.

There was a significantly higher water concentration in the stomach contents in the fish reared in salt water than in the fish reared in fresh water. The drinking of salt water by fish affects the rate of evacuation from the stomach, decreasing the time the ingesta takes to pass through the gastrointestinal tract.

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1.0 INTRODUCTION

Salmonids are the subject of intensive culturing in British Columbia and other parts of the world. Culturing can be a tool for enhancement and management of natural stocks as well as a major source of food production. The major goal of aquaculture is to raise fish to a marketable size in the most economically feasible way. Feed costs can represent up to fifty percent of aquaculture costs; therefore, methods of reducing feed expenditure have been the focus of extensive research.

Formulated balanced diets are created to satisfy the nutritional requirements of growing fish. Salmonids have high dietary protein requirements which have traditionally been supplied by fish meal, the most expensive component of the feed. Protein is required for growth and as an energy source. To minimize the utilization of protein as an energy source, other dietary additions are used to reduce the amount of dietary protein, thus reducing the cost of feeds.

Experiments involving the additions of higher proportions of lipids, plant proteins and carbohydrates to diets have been conducted by many researchers. The effect of the ingredients on the fishes' growth and utilization efficiency has been examined and are considered within this research. The effect of these ingredients on the passage of feed through the digestive tract has been studied to some degree, but further information concerning these effects and their impact on nutrient utilization is required. The rate of passage is influenced by several factors, some of which include feed characteristics, water temperature, stress on the animal, and feeding frequency. The passage time can affect the fish's ability to utilize ingredients of the diet.

The rate of passage of feed can affect the nutrient absorption and utilization. If ingredients within the diets have an adverse effect on absorption, this may result in poor growth rates and feed conversion. It would therefore not be recommended to add such ingredients to the diets in any quantity.

The objective of this study was to examine the effects that different dietary additives have on the gastric evacuation time and feed conversion in rainbow trout (Oncorhynchus mykiss). An additional objective was to examine the effect of water consumption when fish are reared in a marine environment on the water content of the stomach contents and rate of passage of feed.

1.1 LITERATURE REVIEW

1.1.1 History of Rainbow Trout Culture

After carp, Rainbow trout have the longest history in fish culture. They are farmed on all continents and in many countries under various environmental conditions. Records of eyed trout eggs being transferred for culturing from wild stock dates back to 1874 (Gall and Crandell, 1990). Soon after these initial egg transfers, many private and government agencies developed hatcheries for producing rainbow trout for recreational fishing (Gall and Crandell, 1990).

1.1.2 Abiotic Factors

Abiotic factors can affect both the metabolic rate and the processing rate of food in fish. Salmonids are defined as poikilotherms, which means their body temperatures and metabolic rates are governed by the surrounding water temperature.
The optimum temperature for maximum growth rates in salmonids is between 12 and 17 °C, depending on the species (Brett, 1979). Colder temperatures such as 5 °C result in lower feed requirements and reduced growth rates due to a decrease in biochemical reactions resulting in less food being required. In colder temperatures it

has also been noted that protein assimilation of salmonids is impaired if cellulose is incorporated in the diet. The impairment has attributed to the need for more nutrients required for maintenance and therefore less going into growth (Brett, 1979). Temperature also affects the level of dissolved oxygen in the water. Oxygen levels should be maintained with at least 5 - 7 ppm dissolved oxygen (Logan and Johnston, 1990). Flow rates in pens and ponds are important to consider, mainly in relation to oxygen tension. An adequate flow rate will flush away toxic metabolites produced by the fish which can demand oxygen and change the pH of the surrounding environment (Logan and Johnston, 1990).

Photoperiod length has also been found to have a high correlation with growth. An increased day length stimulates endocrine activity in spring, an effect that is enhanced by the rising temperature of the water. The increase in growth is accompanied by an increase in consumption of feed (Brett, 1979).

Rainbow trout have been found to be able to withstand salt water when introduced to full strength sea water after reaching a minimum size, but the response depends on the strain of trout and the location it came from (Gall and Crandell, 1990).

Stocking densities must be considered when culturing rainbow trout. Densities impact growth and feed efficiency and can affect water quality. The potential for disease also increases with increased stocking density (Logan and Johnston, 1990).

1.1.3 Feed Requirements

Feed is the largest component in the cost of trout production, often accounting for over 50% of the operating costs (Logan and Johnston, 1990). It is estimated that up to 5-10% of the feed given to the fish often remains uneaten, falling through the pens or dropping to the bottom of the tank or pond. Trout will eat off the bottom of a cement pond but seldom off the bottom of an earth pond (Logan and Johnston, 1990). The search for the most cost effective method of feeding trout to attain their final or marketable weight has been the subject of extensive research.

Since Salmonids are carnivorous, the major portion of their protein requirements is normally provided as animal protein. In the wild, this consists of zooplankton, invertebrate and vertebrate sea life. Historically, most of the protein in aquaculture diets has been provided by fish meals. Fish meal has been the single most expensive component of salmonid diets (Hilton and Slinger, 1981).

Salmonids are traditionally fed complete diets, both dry and moist, containing two to four times the levels of protein typical of diets for non-carnivorous, warm blooded animals. Reliance on fish meal as the principal protein source for fish feeds, the increased demand for high quality meal, and the decreasing availability of these meals has resulted in alternative sources of protein being investigated. Research into alternative sources of protein has resulted in the assessment and determination of the efficiency of digestion, the available energy contained in fish feeds and the feed intakes (Nose, 1978).

Research has shown that fish eat to satisfy their caloric requirements. When a diet is diluted with an indigestible component, the fish compensates for the decreased caloric content by eating a greater amount of food per day (Grove et al., 1978). Also, diets diluted with these "inert" materials are evacuated from the stomach more rapidly with the rate of emptying increasing with the increasing dilution (Jobling, 1981). Excessive levels of filler may dilute the food to the extent that the fish cannot eat enough to satisfy their needs (Buhler & Halver, 1961; Hilton et al., 1983).

To help decrease the feed cost of intensive culturing, researchers need to obtain precise information on nutritional requirements and components of the diets and their effects on the fish's ability to utilize them. This will result in diets that can be tailored for maximum growth, and an economically practical diet can be manufactured.

1.1.4 Physical Anatomy Of The Digestive Tract

1.1.4.1 Mouth and Oesophagus

As predators, salmonids have well developed oral grasping and holding mechanisms. They have teeth both on the jaws and other surfaces of the mouth. The tongue has sensory taste buds and there are mucous cells scattered throughout the inner lining of the mouth (Reviewed by Iwama, 1989).

The oesophagus is short, wide and muscular. It functions in transport and taste of food. In salmonids, the oesophagus terminates in a cardiac sphincter or valve which separates it from the stomach (Fange and Grove, 1979).

1.1.4.2 Stomach And Associated Gastric Glands

The stomach is a U-shaped distendable organ which can accommodate large meals. It is lined with epithelial tissue and has secretory cells which secrete hydrochloric acid (HCl) and pepsinogen and are stimulated by the distension of the stomach. It is comprised of two sections, a descending or cardiac portion and an ascending or pyloric portion. The cardiac region contains a muscularis mucosa, consisting of an inner circular and an outer longitudinal layer of smooth muscles (Fange and Grove, 1979). The gastric gland cells are active both in acid production and in the synthesis of pepsinogen. The stomach culminates in the pyloric sphincter which is a ring of muscle formed from a thickening of the circular smooth muscle layer, which controls the passage and size of food particles passing from the stomach to the intestine. Mucous membranes provide lubrication to aid in the passage of food. Movement of digesta through the system is controlled by peristaltic waves of muscle contraction (Fang and Grove, 1979). Under stressful situations these muscle contractions are inhibited, which indicates that the peristalsis is under nervous control (Reviewed by Iwama, 1989).

The distention of the stomach stimulates the secretion of digestive enzymes into the stomach. Gastric glands, made up of one type of cell only, contain abundant secretory granules, the cells being active in both acid production and the synthesis of pepsinogen (Fange and Grove, 1979). The pH of the stomach is acidic, between 2 to 4 pH units. Pepsin activity is dependent on pH and temperature, while HCl secretion is dependent on temperature and meal size (Reviewed by Iwama, 1989).

1.1.4.3 Intestine

The intestine is a simple tube which has digestive glands and extensive blood and lymph vessels (Reviewed by Iwama, 1989). The surface area is increased by folds of the mucosa, but the length is less than the body length. The anterior end of the intestine has blind tubes, called pyloric ceca which vary in number between 1 and 1000, depending on the species of teleost. In salmonids, ceca are very well developed and the numbers vary between 30 and 80. The ceca resemble the intestine in structure with a well developed muscularis consisting of circular muscle fibres. The ceca fill with digesta and are discharged by anti-peristaltic action, forcing the digesta down the intestine. The material forced into the ceca already contains digestive enzymes secreted into the intestine. Digestion continues in the ceca where a large part of the digestion and absorption occurs due to the increased surface area. Between the ceca, basophilic pancreatic exocrine gland cells may be present in the connective tissue. Also in this anterior region of the intestine, bile produced in the liver enters from the bile ducts. The inner epithelium of the intestine contains goblet cells which secrete mucus which aids in the passage of ingesta along the intestine. The surface of the intestine contains longitudinal folds which increases the absorptive surface area. The epithelial cells have a brush border of microvilli which further increase the absorptive surface (Fange and Grove, 1979).

Lipase, which breaks down triacylglycerols into mono-glycerides and di-glycerides, is released by the pancreas into the intestine and is present in the digesta in the pyloric ceca. Absorption of the fat occurs in the anterior portion of the intestine (Reviewed by Iwama, 1989). However, as stated previously, absorption may occur further along the intestine under heavy lipid loading.

The terminal part of the intestine is differentiated by an area in which the rectum is wider and is separated from the intestine by an ileo-rectal valve formed of smooth muscle. The mucosal epithelium is richly endowed with goblet cells and contains a brush border of microvilli for increased absorptive capacity. The rectal gland is believed to secrete salt ions into the lumen to aid in osmoregulation in high salt environments (Fange and Grove, 1979). Mucous cells are present in the rectum. The vent is the terminal location of the urinary and intestinal tracts (Reviewed by

Iwama, 1989).

1.1.4.4 Associated Glands and Organs

The liver is a two-lobed organ with a variety of functions. The hepatocytes contain numerous mitochondria, endoplasmic reticulum, golgi apparatus, lysosomes and peroxisomes as well as lipid and glycogen deposits. The liver produces bile. The excess bile is stored in the gall bladder and the bile duct opens into the anterior intestine. Bile salts aid in fat digestion through emulsification and aid in adjustment of the pH in the intestine to the desired neutral or basic pH (Reviewed by Iwama, 1989).

The pancreas is diffuse in salmonids, and is scattered amongst, and associated with, fatty material around the pyloric ceca. It secretes not only insulin and glucagon in response to blood concentrations of amino acids and glucose, but also digestive enzymes through the pancreatic duct into the anterior intestine.

Pancreatic enzymes include trypsin, chymotrypsin, lipase, amylase, carboxypeptidases, and elastase (Fange and Grove, 1979). Bicarbonate, secreted by the pancreas, increases the pH of the egesta from the stomach. The pancreatic enzymes are most active at neutral to basic pH.

1.1.5 Carbohydrates and Fibre in Fish Diets

Salmonid fish, such as rainbow trout, are mainly carnivorous and can not utilize carbohydrates efficiently (Shiau et al., 1988). Carbohydrates, as alternate energy sources, have been shown to be used with low efficiency due to insufficient enzymatic break-down in the digestive tract, insufficient absorption of the end products of digestion and insufficient metabolization of absorbed monosaccharides. Complex carbohydrates must be broken down to simple sugars before the nutrients can be absorbed. Trout have been found to be able to utilize alternate energy sources such as digestible carbohydrates, sucrose and gelatinized starch (Peiper and Pfeffer, 1979).

Hilton and Atkinson (1982) found that trout maintained on high carbohydrate diets had poor glucose tolerance and that the provision of diets with digestible carbohydrates in excess of 140 $g.kg^{-1}$ resulted in significant growth depression. The reported tolerance of rainbow trout for glucose varies among experiments. Buhler and Halver (1961) found that chinook fingerlings could tolerate 48% carbohydrate diets without enlarged glycogen-rich livers on mortality, as long as their diet was nutritionally adequate. Divergent results may be due to the difference in the age, size of fish, water temperature, type of carbohydrate, and method of feeding, i.e. single versus multiple meals (Hilton and Slinger, 1981).

Digestibility of starch is poor in salmonids. Even though cooking or heating starch improves its digestibility, the fish's ability to utilize glucose is still limited. High glucose diets can result in larger livers and high liver glycogen levels, and can cause decreased growth and increased mortalities, especially in cold water temperatures (Hilton and Slinger, 1981). However, the fish's ability to utilize carbohydrates may depend on the type of carbohydrate and its effect on gastric motility.

Fish with simple stomachs have limited microbial action in the gut due to the small capacity of the digestive system, the short food retention time and the low temperature. Fish have a very limited ability to utilize fibre (Smith, 1978).

It has been the practice in fish feed formulation for experimental studies to adjust nutrient balance by introducing fibre as filler or as a stabilizer for pellet formation in high density diets. Also, the use of carbohydrates which contain varying amounts of fibre is common (Buddington and Hilton, 1988). Fibre has been thought to be indigestible and therefore of no consequence to the caloric content or nutrient value of the diet. However, fibre may affect the availability of other nutrients by altering the rate of passage of digesta through the gastrointestinal tract (Hilton and Atkinson, 1982).

Dietary fibre includes indigestible plant materials such as cellulose, lignin and other complex carbohydrates. Fibre can be divided into viscous or water soluble polysaccharides such as guar gum, pectin, and carboxymethyl cellulose and non-viscous or water insoluble polysaccharides such as alpha-cellulose. The use of binders such as alginates, which have a water-binding effect in the intestine, may also have an anti-nutritional effect (Storebakken and Austreng, 1987). Dietary fibre affects the movement of nutrients along the gastrointestinal tract and likely influences the nutrient absorption (Shiau et al., 1988). Juvenile rainbow trout reared on 10 to 20% cellulose diets adapted to increased dietary fiber by increased feed consumption, increased gastric evacuation time and increased stomach volume. Gastric emptying time was much faster on high fiber diets (Hilton et al., 1983).

Fibre has been shown to interfere with the absorption of many nutrients such as bivalent metals, fats and amino acids (Southgate & Durin, 1970). With rats, fibre has been shown to alter gastrointestinal mucin quantities and to bind to the mucin which can affect nutrient absorption (Satchithanandam et al., 1990). Both dietary fibre and fibre isolates have been found to sequester bile salts and bind fatty acids thereby decreasing the availability of cholesterol and the by-products of triacylglycerol digestion (Vahouny et al., 1981).

The practice of including fibre and carbohydrates as fillers and binders in the diet may have a negative effect on the nutrient uptake, thereby affecting the growth of fish. Viscous polysaccharides such as guar gum and pectin appear to slow gastric emptying (Leeds, 1982).

1.1.6 Digestion and Absorption of Nutrients

1.1.6.1 Protein Digestion and Absorption

Food intake distends the stomach which stimulates the release of HCl and pepsinogen. This brings the pH of the stomach to between 2 and 4. Pepsin is the major acid protease which is secreted by the gastric gland cells and is active at the pH levels created by the HCl. Pepsin is the first enzyme to cleave peptide linkages in the dietary proteins within the feed (Fange and Grove, 1979). The release of HCl and pepsinogen is stimulated by the hormone gastrin. The distention of the stomach stimulates the vagal nerve which in turn activates secretion of gastrin from the cells in the stomach (March, 1990). The digestion of protein begins in the stomach with the endopeptidase activity breaking down the protein into a slurry (Fange and Grove, 1979).

As the digesta passes from the stomach into the intestine, the presence of this acidic mixture stimulates the secretion of the hormone secretin. This in turn stimulates the secretion of pancreatic juices with bicarbonate compounds to increase the pH to a neutral or basic level. The intestinal digestion of proteins continues with the release of trypsin and chymotrypsin which further split the polypeptides. Carboxypeptidases and peptiadases in the intestine further break down the bonds of the protein. Enzymes such as elastase and collagenase may attack specific protein bonds. Elastase, which is activated by trypsin is active in breaking peptide bonds in the protein elastin (Fange and Grove,1979).

The proteins continue to break down until they are low molecular peptides and individual amino acids. The amino acids are absorbed against concentration gradients, coupled with inorganic ions (Fange and Grove, 1979). Peptides are most likely to be absorbed by pinocytosis.

1.1.6.2 Lipid Digestion and Absorption

Lipids in fish diets are hydrolysed by lipases and phospholipases and are subsequently used either as an energy source, stored as fat deposits, or incorporated into phospholipids in tissues (National Research Council, 1973). Lipases released by the pancreas are the major factor in fat digestion (Fange and Grove, 1979). Lipase is secreted into the upper intestine and pyloric ceca where a great deal of lipid digestion and absorption occurs (Fange and Grove, 1979).

Lipids are not soluble in water. Lipases hydrolyse neutral fat into diglycerides, monoglycerides, glycerol and free fatty acids (Fange and Grove, 1979). Lipids are emulsified and solubilized prior to hydrolysis with the aid of bile salts released with the bile. The bile salts and lipids form micelles which then can be absorbed. Next, the lipid is formed into chylomicron or very low density lipoprotein particles and absorbed into the lymph

(Fange and Grove, 1979). This mainly occurs in the proximal intestine or in the pyloric caeca. If there is excessive dietary lipid, the absorption could extend to the distal intestine (Leger, 1985). Lipids are slow to be absorbed, and this may depend on the gastric emptying and intestinal transit rates as well as on the temporary storage of lipids in the enterocyte (Leger, 1985).

1.1.6.3 Carbohydrate Digestion and Absorption

Salmonids are not efficient users of carbohydrates; however, trout do have the necessary enzymes to split disaccharides and starches into monosaccharides for absorption. The pyloric caeca and upper intestine contain digestive enzymes such as maltase, sucrase, lactase and amylase. Carbohydrates are absorbed as simple sugars. The trout's ability to use carbohydrates as energy is limited (National Research Council, 1973).

Carbohydrates are used in commercial feeds because they are generally inexpensive and they aid in stabilizing and binding the pellets (Hemre et al., 1989). In addition, carbohydrates may supply up to 20 % of the available calories with a protein-sparing effect. Cereal grains, which are often in diets for mammals, contain starch; however, starch is poorly digested by salmonids. The digestibility of starch can be improved by heat processing and the end product of starch digestion is glucose. In an experiment with rainbow trout, glucose gave an absorption of 90%. There was a rapid increase in blood glucose which took 24 hours to return to initial levels (Hemre et al., 1989). The inability of rainbow trout to regulate glucose in the blood may be partly due to a lack of glucose phosphorylating capacity (Cowey et al., 1977)

Carbohydrates can also affect the glycogen content in the liver. Large loading of starch in the diet can result in enlarged livers with high liver glycogen levels, depressed growth and increased mortalities (Hilton and Slinger, 1981).

Fibre, such as cellulose, has a very low digestibility and can adversely affect the absorption of other nutrients as well, as indicated previously.

1.1.7 Food Passage Time Through the Gastrointestinal Tract

Gastric evacuation rates are altered by metabolic rate changes which change with water temperature, oxygen level, light intensity and stress. Other factors, which may influence the rate of passage, include the frequency of feeding and the characteristics of the feed. Evacuation time is dependent on the amount of food in the stomach, the variation in the food or prey size, and meal size (Mills et al.,1984). These factors also influence the rate of feed intake and determine the stomach volume.

Gastric evacuation in sockeye salmon was shown to take approximately twice as long when water temperatures were decreased from 23 °C to 10 °C (Cho, 1990). Elliot (1991) found that evacuation rates in brown trout increased with temperature. In juvenile chum salmon grown under different temperature regimes, 8,10,12, 14 and 16 °C, the dry weight of the stomach contents decreased exponentially over time (Koshiishi, 1980). Koshiishi also found that rates were not significantly affected by temperatures between 8 and 12 °C in small fish (0.7 g) but larger fish (2 g) needed a shorter time for evacuation as temperature increased. Rogers and Burley (1991) found that smallmouth bass, on a diet of juvenile salmon, had an increase in total evacuation rates with an increase in water temperature. Similar results were found in rainbow trout (Fauconneau et al., 1983).

Robb (1990) found that in whiting, larger fish eliminated meals at a faster rate than smaller fish with meals of a given size following a linear evacuation model. However, larger meals eliminated faster grams per hour but took longer to evacuate by virtue of their size. Jollivet et al.(1988) had similar results with turbot in that a smaller daily ration (0.5% of the test animal's body weight) evacuated more rapidly that larger rations. Santos and Jobling (1991), contrary to Robb's findings, found that cod of different size fed fixed proportions of their body weight evacuated at a constant rate independent of their body size. Garber (1983) found that in yellow perch, gastric evacuation rates were not affected by the size of the fish or by the dietary moisture. The meal size resulted in variations in the total evacuation rate, although the differences were not proportional to the changes in meal size. Nagata (1989) found that a square root model described gastric evacuation in juvenile masu salmon most closely. Smithe et al. (1989) found that walleye pollack fed a range of meal sizes, 0.5% to 2.5% of the test animals' body weight, evacuated food as a negative exponential function of time. An increased in the amount of food eaten at one time resulted in a decrease in the total evacuation rate but an increase in the amount of food evacuated. Smithe et al. (1989) also found that an increase in temperature resulted in an increased evacuation rate as a linear function when pollack were grown in temperatures ranging from 3 to 9 °C. Ryer and Boehlert (1983) also found that evacuation rates were temperature dependant with more rapid evacuation occurring with increased temperature; and that the evacuation rate is positively correlated to gut content, the rate slowing with decreasing gut content. This may allow for increased efficiency for assimilation during periods when there is little food available.

Models to describe gastric evacuation rates are varied. Jobling (1981, 1986) suggested that evacuation of large prey follow a linear or square root curve. Ruggerone (1989) found that a exponential curve model fitted overall evacuation more closely. Robb (1990) indicated that a linear evacuation model gave a good description of the data for whiting.

Meal size can affect the rate of digestion. The rate of digestion is proportional to surface area of the food bolus. Enzymes attack the bolus at the surface; therefore, a smaller meal will be digested more quickly. Larger fish will digest a meal that is 1% of its body weight at a greater rate than a smaller fish; but, the time required for complete digestion will be longer (Fange and Grove, 1979). An increase in meal size (as a percentage of body weight) increases both the residence time of food in the stomach and the rate of evacuation (Talbot et al., 1984).

Periods of starvation and stressful procedures, such as force feeding affect the feeding and digestive processes in fish. Forced feeding of test animals usually decreases the rate of evacuation of the meal from the stomach when compared with fish that fed ad lib (Fange and Grove, 1979). Fish that have been deprived of food for some time prior to feeding show a slower gastric emptying rate; only 50 to 68% of the rates found in actively feeding fish (Fange and Grove, 1979). Talbot et al. (1984) found that periods of starvation affected the evacuation rate independent of the effects of meal size and fish size. Fish that were prevented from ingesting further meals had a slower evacuation rate. Fish that were starved prior to the feeding trial consumed a larger meal (as a percentage of body weight) than fish that were not. Therefore, the rate of passage will not be representative of fish under growing conditions with a normal feeding schedule. Fish that are stressed due to handling or disease will also have altered passage times.

1.1.7.1 Characteristics of Feed Which Affect Passage Rates

The type of food will affect the gastric emptying rate. Digestibility of the food will affect the speed of gastric emptying and will also determine the length of time post-prandial before the decrease of the stomach contents occurs. Fish compensate by increasing their intake when their diet is diluted with material that reduces the caloric content (Grove et al., 1978).

Before fibre and lipids are incorporated into a diet to bulk, bind or add caloric content to the diet, consideration should first be given to the effects that these additions may have on the passage of the feed through the digestive tract and the resulting effect on absorption of nutrients.

Lipids

Practical trout diets normally contain between 6 and 14% crude fat (Hilton and Slinger, 1981). To maintain an adequate level of energy and the required concentrations of omega-3 and omega-6 fatty acids in the diet, ingredients are supplemented with animal, marine or vegetable fats. Diets with 15 to 20% lipid levels are beneficial, the higher level of lipids having a protein-sparing effect. This allows the quantity of protein required in the diet to be decreased, providing an economic advantage. However, high lipid levels can cause difficulty in pelleting and crumbling of the diet and a potential for oxidation of the lipids (Hilton and Slinger, 1981). The effect of higher lipids incorporated into the diets must be considered when formulating the diet. The level of protein combined with the lipid levels also must be considered. Bromley (1980) found that turbot grown on high lipid diets with restricted amounts of feeds had a reduced growth in weight and length due to the decreased amount of protein in the diet, even though there was a high level of lipid. Therefore, adequate protein for growth is required before lipid can have a protein-sparing effect.

Diets with increased fat levels decrease gastric evacuation rates in rainbow trout. The presence of fat in food may delay emptying by a release from the intestinal wall of a hormone similar to enterogastrone which, in mammals, inhibits gastric motility (Fange and Grove, 1979).

Fibre

Fish adjust their dietary energy intake to digestible energy levels in the diet. It has been found that fish that have been starved and then resume feeding have decreased evacuation rates (Elliott, 1991). Diets diluted with inert material are evacuated more rapidly as increased dilution speeds up the gastric emptying time (Jobling, 1981). Trout, like turbot, will increase their feed intake to partly offset a decreased energy supply (Grove et al., 1985). Hilton et al. (1983) found that rainbow trout had a faster gastric emptying time on high fibre diets versus control or basal diets; however, there was no apparent difference between diets of 10 and 20% fibre. Hilton et al. (1983) suggested that a rapid gastric evacuation is a physiological adjustment of trout designed to permit increased consumption of low energy diets. In contrast, Fange and Grove (1979) found decreased evacuation rates with less digestible foodstuffs; the digestibility of food stuffs affecting not only the rate of gastric evacuation but also the time after eating before stomach contents begin to leave the stomach. These results can both be true in that gastric emptying times vary with such factors as species, fish size, temperature and food type. The method of acquiring the passage information can affect the results. Additions of bran, cellulose or guar gum to a meal for humans caused gastric evacuation to take longer (Eastwood and Brydon, 1984). Fibre may limit nutrient intake and will increase faecal waste production (NRC, 1983). Carbohydrate gelling agents, such as quar gum, pectin, and carrageenin may delay gastric emptying or impair absorption within the small intestine due to the altered diffusion rate or by binding with fibre constituents (Elsenhans <u>et al.</u>, 1980). Pectin has been found to impair intestinal absorption and reduce postprandial blood glucose and insulin concentrations in rats (Elsenhans <u>et al.</u>, 1984).

<u>Moisture</u>

Fish grown in salt water have been found to drink water continuously while fish in fresh water drink very little (Fange and Groves, 1979). Marine fish swallow water to between 5 to 12% of their body weight daily (Fange and Groves, 1979). In sea raised trout, a syndrome of distended, water-filled stomachs have been found to occur where fish are grown in water of high salinity (sea level and higher), and low temperatures. Fish displaying this syndrome have, amongst other symptoms, distended stomachs that are approximately 2 to 6 times the normal stomach size, with a higher moisture level of stomach content. High lipid levels, above 25%, in the diet appear to cause a higher frequency of stomach distention. The accumulation of lipid in the stomach can be expected to influence digestion, absorption and metabolism (Staurnes et al., 1990). Garber (1983) found in yellow perch that evacuation rates were not affected by dietary moisture. However, if there are ingredients within the diet, such as guar gum, which have greater water holding capacities, the evacuation rates may be affected by the dietary moisture.

Binders

Binders, such as alginates, are used in fish diets to reduce wastage from moist and wet feeds. It is important to know how the binders act in the gastrointestinal tract in order to use them effectively. When bran, cellulose and guar gum were added to human diets, guar gum was found to have the longest passage time, which may be related to its greater water-holding capacity. More viscous meals are emptied more slowly from the stomach (Eastwood and Brydon, 1984).

Storebakken and Austreng (1987) added alginates to moist diets, at levels up to 5% of the dry weight of the feed. They found that the water-binding effect of the alginates in the intestine was evident by the increased water content of the faeces.

1.1.7.2 Methods of Measurement of Passage Time

Methodology of measuring gastric emptying rates can be complicated by the handling of the test animals. A variety of techniques has been used to study the passage time of digesta. One method is to kill fish after they have been fed a diet to determine the extent of stomach emptying over time. The degree of breakdown has been measured visually, by volume with both wet and dry weights and by caloric and biochemical analysis of the residue. Other studies have induced vomiting and used stomach pumps to collect the residue (Fange and Grove, 1979). Methodology of collecting measurements of gastric emptying rates can be complicated by the handling of the test animals.

X-radiography has been used on trout during digestion. A labelled isotope can be incorporated into the food to monitor food motility by X-ray techniques (Grove et al., 1978).

Other techniques have included incorporating dye markers into the diet. Digestion rates have been estimated by correlating the time of feeding to the appearance of the dye in faeces; however, there can be a problem with fish that ingest large meals. The dye can appear in the faeces while part of the original meal is still in the stomach. This technique is also based on the premise that the inert marker passes through the digestive tract at the same rate as the rest of the meal (Fange and Grove, 1979). As discussed previously, different types of materials within the diet can affect the passage time. Markers must be non-absorbable, not irritate the gut and not stream in the digestive tract.

2.0 Experiment 1

2.1 Introduction

Experiment 1 consisted of feeding trials involving three experimental diets and one control diet as described above. The effect on gastric emptying was determined through a time series dissection. The diet additions included: cellulose, a water insoluble fibre which is commonly used to bulk up the diet; pectin, a water soluble fibre which could be used as a binder and add bulk to the diet; and, an increased level of lipid as an additional energy source.

2.2 Materials and Methods

2.2.1 Experimental Design

Experiment 1 was carried out over a 26-day period, during which time the fish were fed to satiation once daily in the morning. The fish were weighed prior to the start of the experiment and again at the end of the experiment. The feed consumption per tank was measured daily and on completion of the experiment.

The fresh water facility consisted of 16 fresh water tanks of approximately 150 L each. Each tank had a central standpipe sleeve to allow for water circulation and flushing. Vancouver city water was dechlorinated by a sodium thiosulphate injection system. A heat exchanger maintained the water at temperatures between 6.3 and 7.0 °C. The oxygen levels were between 6.4 to 10.8 ppm. The passage through the gastrointestinal tract was determined by dissection of the stomach and intestine at timed intervals following feeding. The fish were fed on the final day of the experiment and the contents of the stomach and intestine were removed and weighed at 1, 6, 12, 18 and 24 hours post-prandial. The fish were anaesthetized and weighed. They were then decapitated, opened, and the stomach and intestinal contents removed separately and weighed.

2.2.2 Experimental Fish

There were 144 fish which were anaesthetized, weighed and sorted; fish with outlying weights were removed in an attempt to standardize the population. The fish were weighed prior to the start of the experiment before the feeding regime began and again at the end, after final feeding to determine the weight gain. At the beginning of the experiment the fish weighed between 200 and 440 g. The fish were randomly distributed into 16 tanks with 9 fish per tank. The mean fish weight per tank was 280.4 g ± 23.77 g. The fish were treated for fin and tail rot 1 week prior to sorting.

There were four replicates of each diet. The diets were assigned to the tanks randomly to eliminate location bias. The tanks had an initial stocking density of 280.41 gram mean weight in 150 litres of water to equal 1.87 g/l.

2.2.3 Diet Preparation and Composition

The diets were prepared in the laboratory of the Department of Animal Science at the University of British Columbia. Vitamin and mineral premixes were compiled in the required amounts before addition to the diets. Herring oil was used to coat the diets to bring them to the desired lipid levels. The compositions of the diets and the vitamin and mineral premixes are presented in Tables 1 and 2, respectively.

2.2.4 Experimental Protocol

The fish were fed a commercial diet for the first week. For 4 days prior to the experiment, increasing amounts of the experimental diets were introduced. By the fourth day the experimental diets were the only source of nutrients.

TABLE 1: DIET FORMULATION FOR EXPERIMENT 1

BASAL DIET INGREDIENTS	g/kg Diet	g Protein/ kg of Diet	g Lipid/ kg of Diet
HERRING MEAL	500	367.60	46.20
GROUND WHEAT	300	43.17	5.58
OIL - SARDINE	50		50.00
CALCIUM MONO-PHOSPHATE	10		
PREMIX	30		
CALCIUM LIGNOSE SULPHONATE	30		
WHEY	30	3.60	0.24
FISH SOLUBLES	50	15.75	3.90
DIET	**% OF BASAL**	**% INGREDIENT OF DIET**	**% MOISTURE**
DIET 1	100	0.0	13.4
DIET 2	88	12.0 FISH OIL	11.8
DIET 3	88	12.0 PECTIN	11.8
DIET 4	88	12.0 CELLULOSE	11.8

TABLE 2: VITAMIN AND MINERAL PREMIX FOR EXPERIMENT 1

VITAMIN	mg/kg fed
Thiamine HCl	60.00
Riboflavin	100.00
Niacin	400.00
Biotin	5.00
Folic Acid	25.00
Pyridoxine.HCl	50.00
Vit. B_{12} - Cyanocobalamine	0.10
D-Calcium Pantothenate	200.00
Vit. C - Ascorbic Acid	1500.00
Choline Chloride (60%)	4000.00
Inositol	2000.00
Vit. A Retinyl Palmitate	10000.00
Vit. D_3 - Cholecalciferol	300.00
Vit. E - DL-α-tocopherol Acetate	1000.00
Vit. K Menadione	30.00
MINERALS	**mg/kg fed**
Magnesium as $MgSO_4$	380.00
Manganese as $MnSO_4.5H_2O$	30.00
Zinc as ZnO	70.00
Iron as $FeSO_4.7H_2O$	85.00
Copper as $CuSO_4.5H_2O$	2.00
Cobalt as $CoCl.6H_2O$	0.003
Iodine as KIO_3	5.00
Fluorine as NaF	4.50
Selenium as $Na_2SeO_3.5H_2O$	0.10

The fish were fed once daily to satiation on the experimental diets for 26 days. After feeding on the 26th day five fish per diet were selected at 1, 6, 12 and 18 hours post prandially. At 24 hours, the remaining fish were sampled which resulted in four or five fish per diet[1]. The fish were anaesthetized immediately after selection to minimize ingesta loss. The fish were killed, the contents of the stomach removed and weighed. The intestine was also dissected and the contents removed and weighed. Fish which had not fed were recorded as empty.

All results were analyzed using Analysis of Variance (ANOVA) using SYSTAT (Wilkinson, 1989), with differences between means tested at $P \leq 0.05$, using Tukey's multiple range test. Analysis of Variance was carried out on the data to determine if there were any significant tank effects. Since none was shown, the subsequent analysis was carried out on the pooled data for the fish in the tanks.

2.3 Results

The initial and final weights of fish, feed utilization and growth are summarized in Table 4. The stomach contents and intestinal contents over the passage time are individually shown in Appendix 1 and 2. For detailed results of stomach and intestinal contents by diet see Appendix 3.

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[1] A portion of the fish were used in another experiment for blood sampling.

2.3.1 Feed Consumption and Weight Gain

There was no significant difference in the initial weights of the fish between the different diets. There was a significant difference between diets for the amount of feed eaten and for the weight gain in conjunction with the amount of feed eaten. The results are summarized in Table 3.

TABLE 3: RELATIONSHIP OF FEED CONSUMPTION TO BODY WEIGHT GAIN IN RAINBOW TROUT REARED ON 4 DIFFERENT DIETS IN FRESH WATER, EXPERIMENT 1

DIETS	AMOUNT OF DIET EATEN AS FED PER FISH (g)	FISH WEIGHT (COVARIATE OF AMOUNT OF DIET EATEN AS FED) (g)
DIET 1 BASAL	$72.2^{A} \pm 13.5$	$51.7^{A} \pm 18.8$
DIET 2 HIGH LIPID	$65.5^{AB} \pm 6.4$	$49.8^{A} \pm 11.0$
DIET 3 PECTIN	$35.0^{B} \pm 8.3$	$18.3^{B} \pm 11.6$
DIET 4 CELLULOSE	$73.5^{A} \pm 12.4$	$38.1^{C} \pm 17.3$
SAMPLE NUMBERS	N=16	N=16

NB: Values with unlike superscript letters were significantly ($P \leq 0.05$) different according to Tukey's test.

Tukey's test was used to test for differences between the means. The basal diet (Diet 1) and the cellulose diet (Diet 4) at P = 0.006, indicated that there was a higher weight gain in the fish fed on the basal diet; the high lipid diet (Diet 2) and the cellulose diet (Diet 4) at P = 0.001 indicated that there was a higher weight gain for the fish fed Diet 2; and, between the pectin diet (Diet 3) and the cellulose diet (Diet 4) at P = 0.025

indicated that there was a higher weight gain in the fish fed on the cellulose diet.

The quantities of feed eaten and weight gained by diet and tank are listed in Table 4. The pectin diet (Diet 3) was consumed less and resulted in poorer weight gain than all other diets. There was a significant difference in weight gain for the high lipid diet (Diet 2) compared to the cellulose diet when the amount of feed eaten is considered. Diet 2 had the lowest feed-to-weight gain ratio and therefore a better feed conversion. The cellulose diet (Diet 4) was significantly different than all other diets for weight gain when the feed per fish eaten is considered. The fish fed this diet gained less weight than fish fed either the basal diet or the high lipid diet but more than those fed the pectin diet.

TABLE 4: EXPERIMENT 1, FEED CONSUMPTION AND WEIGHT GAINS OF RAINBOW TROUT REARED IN FRESH WATER (9 FISH/TANK)

DIET	TANK #	FEED EATEN (g)	FEED /FISH (g)	MEAN INITIAL FISH WEIGHT (g)	MEAN FINAL FISH WEIGHT (g)	WEIGHT GAIN (g)	FEED/ WEIGHT GAIN
BASAL 1	15	698.7	77.6	279.8	343.5	63.7	1.22
1	11	740.3	82.3	310.6	374.1	63.5	1.29
1	13	718.9	79.9	310.8	371.0	60.2	1.33
1	1	441.0	49.0	270.1	289.4	19.3	2.54
MEAN SD		649.7 121.4	72.2 13.5	292.8 18.2	344.5 34.0	51.7 18.8	1.60 0.55
HIGH LIPID 2	16	684.9	76.1	256.2	324.4	68.2	1.12
2	14	584.1	64.9	260.7	308.9	48.2	1.35
2	7	531.1	59.0	286.9	327.8	40.9	1.44
2	6	559.6	62.2	293.5	335.4	41.9	1.48
MEAN SD		589.9 58.0	65.5 6.4	274.3 16.1	324.1 9.6	49.8 11.0	1.35 0.14
PECTIN 3	10	341.8	38.0	285.9	284.6	0.0*	0.00*
3	3	397.8	44.2	253.9	278.3	24.5	1.81
3	8	529.8	58.9	292.3	323.5	31.2	1.89
3	5	402.3	44.7	264.4	281.9	17.5	2.56
MEAN SD		417.9 68.9	35.0 8.3	274.1 15.6	292.1 18.3	18.3 11.6	1.56 0.95
CELLULOSE 4	2	801.2	89.0	302.0	361.7	59.6	1.49
4	4	718.0	79.8	296.2	346.6	50.4	1.58
4	9	500.3	55.6	220.6	239.6	19.0	2.93
4	12	625.0	69.4	302.6	326.0	23.5	2.96
MEAN SD		661.1 111.8	73.5 12.4	280.4 34.6	318.5 47.3	38.1 17.3	2.24 0.70

NB: * = A NEGATIVE WEIGHT WHERE THE FISH LOST WEIGHT IN THIS TANK, RECORDED AS ZERO.

2.3.2 Evacuation of the Stomach Contents Over Time

The data from the stomach contents as a percentage of fish weight for the fish fed on the different diets are summarized in Table 5. In Figure 1, there appears to be a difference at 12 hours between Diet 3 and the rest of the diets. However, Analysis of Variance showed no significant differences (P=0.108).

TABLE 5: EXPERIMENT 1, STOMACH CONTENTS OF FISH GROWN IN FRESH WATER (Average Wet Weights of stomach contents As % body Weight) AT DIFFERENT TIMES POST PRANDIAL

HOURS POST FEEDING		DIET 1 CONTROL	DIET 2 12% ADDED LIPID	DIET 3 12% ADDED PECTIN	DIET 4 12% ADDED CELLULOSE
1	MEAN	2.49	2.13	2.95*	3.34
	SD	0.90	1.03	0.77	1.80
6	MEAN	2.57*	1.33	2.04	2.28
	SD	0.57	0.87	1.13	1.28
12	MEAN	0.81*	0.53*	1.87*	0.61
	SD	0.43	0.69	0.71	0.45
18	MEAN	1.46*	0.83*	1.22	0.65
	SD	0.66	0.66	0.31	0.28
24	MEAN	0.28*[AC]	0.43[AC]	0.03**[B]	1.23[C]
	SD	0.19	0.28	0.01	0.52

*= One fish was empty, data removed from mean
** = Three fish were empty, data removed from mean. The mean represents only 2 fish.
NB 1: When both the stomach and the intestine were empty of contents, it was assumed that the fish did not eat and therefore it was not included in the data. After 12 hours, if the intestine had contents, the stomach contents were included in the mean even if the stomach was empty. Stomach contents were recorded as zero.
NB 2: Mean values with unlike superscript letters were significantly ($P \leq 0.05$) different according to Tukey's test.

As indicated in Table 5, over 50% of the digesta was evacuated by 12 hours with the exception of Diet 3, the pectin diet. This took up to 18 hours before 50% of the feed was evacuated as seen in Figure 1. The cellulose diet (Diet 4) was the diet with largest quantity of ingested material (as determined by the 1 hour dissections), and the contents left the stomach at a faster rate than any of the other diets. Figure 1, shows that both the cellulose diet (Diet 4) and the high lipid diet (Diet 2) evacuated to 50% of the initial fill by approximately 8.25 hours. The control diet (Diet 1) took 9 hours to evacuate to 50% of the initial contents and the pectin diet took 15.75 hours to evacuate to 50% of the initial quantity.

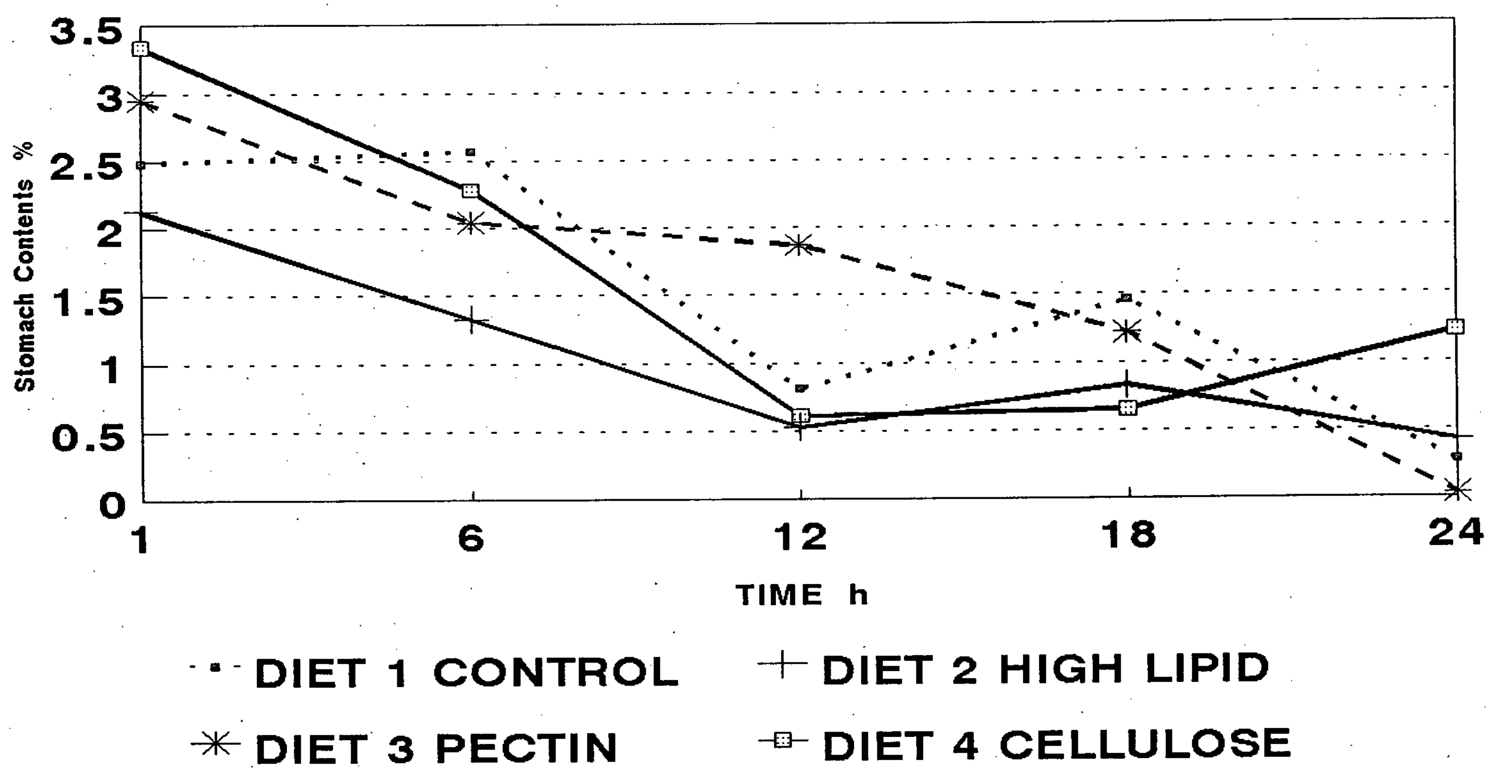
The change in stomach fill from 1 hour sampling to 12 hours sampling can be used to give a rate for the contents evacuated per hour. The cellulose diet evacuated the stomach the quickest, and the pectin diet remained in the stomach the longest. The different diets were evacuated at: control diet (Diet 1) 0.153 g/h; the high lipid (Diet 2) 0.146 g/h; the pectin diet (Diet 3) 0.098 g/h; and, the cellulose diet 0.248 g/h.

When the data were statistically analyzed, no significant difference among responses to the diets were found except for samples taken at 24 hours (P=0.018). Tukey's test showed differences between the control diet (Diet 1) and the pectin diet (Diet 3), and Diet 3 and the cellulose diet (Diet 4) at P=0.043 and P=0.029, respectively.

The cellulose diet (Diet 4) took longer to fully evacuate from the stomach than did either the control diet (Diet 1) or the pectin diet (Diet 3). However, after 12 hours, most of the stomachs were empty. The major movement of stomach contents occurred prior to 12 hours with the exception of the pectin diet (Diet 3). The sample size for Diet 3 at 24 hours was very limited (only two fish).

There is a large variation in data due to the differences of feed consumption for individual fish. Larger numbers of experimental fish would be needed to reduce the variation. The passage time for each fish sampled is represented graphically in Appendix 1.

FIGURE 1: STOMACH CONTENTS OF RAINBOW TROUT REARED ON 4 DIFFERENT DIETS IN FRESH WATER



Experiment 1
Weight of stomach contents as a percent
of body weight

2.3.3 Evacuation of Intestinal Contents Over Time

The data for the passage of digesta through the intestine is shown in Table 6.

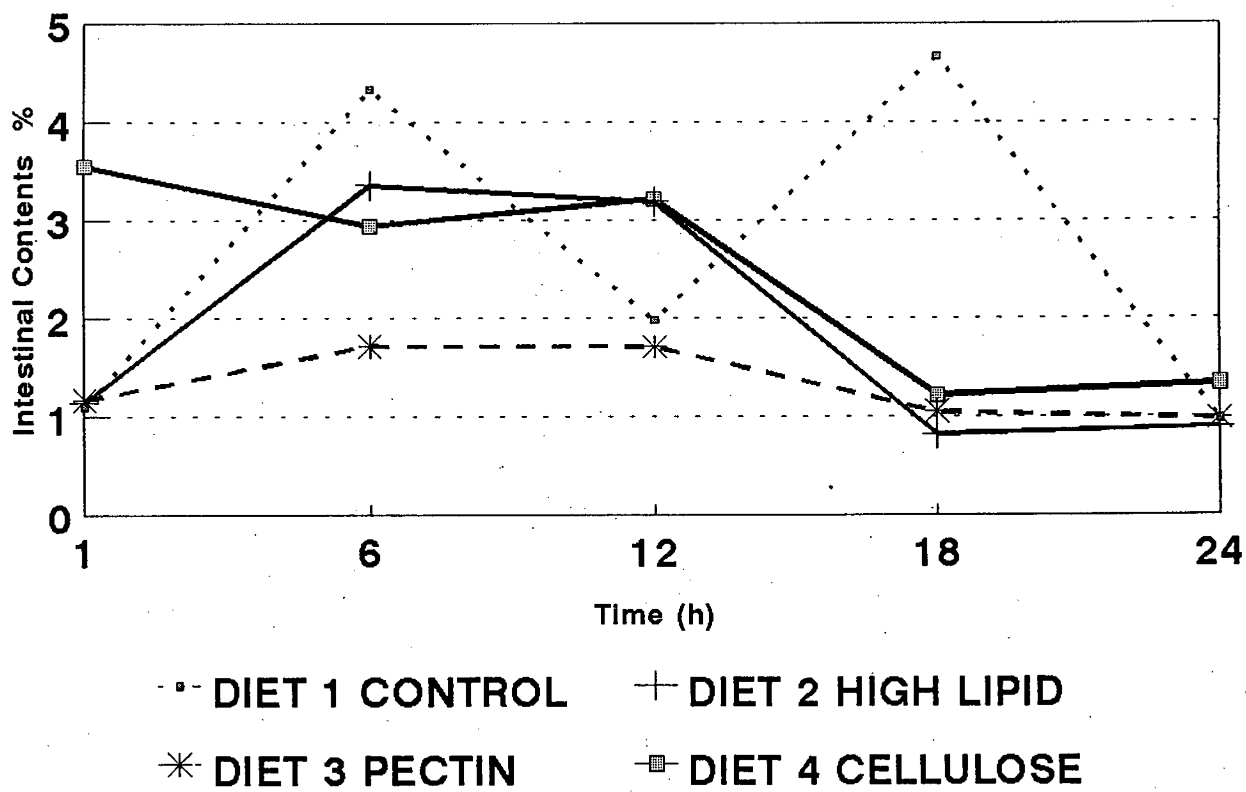
TABLE 6: EXPERIMENT 1, INTESTINAL CONTENTS OF FISH GROWN IN FRESH WATER (Average Wet Weights of intestinal contents as % body Weight) AT DIFFERENT TIMES POST PRANDIAL

HOURS POST FEEDING		DIET 1 CONTROL	DIET 2 12% ADDED LIPID	DIET 3 12% ADDED PECTIN	DIET 4 12% ADDED CELLULOSE
1	MEAN	1.10	1.15	1.17*	3.55
	SD	0.38	0.30	0.47	0.68
6	MEAN	4.33*	3.36	1.72	2.94
	SD	1.68	1.33	0.93	1.62
12	MEAN	1.98	3.19	1.71*	3.22*
	SD	1.10	1.53	0.71	2.17
18	MEAN	4.67	0.82*	1.05	1.22
	SD	1.57	0.28	0.61	0.31
24	MEAN	0.98	0.90	0.98	1.34
	SD	0.52	0.56	0.32	0.30

*= One fish was empty, data removed from mean
NB 1: When both the stomach and the intestine were empty, it was assumed that the fish did not eat and therefore it was not included in the data.

There were no significant differences found between the amounts of intestinal contents of fish reared on the different experimental diets at any time.

FIGURE 2: INTESTINAL CONTENTS OF RAINBOW TROUT REARED ON 4 DIFFERENT DIETS IN FRESH WATER



Experiment 1
Weight of intestinal contents as a percent of body weight.

2.4 Discussion

All data indicated a large range of values, making comparisons and conclusions difficult. The fish population initially was diverse, and the poor selection of available fish from which to select a standardized population created a test group of fish with a wider variation in weight than desired. There were some signs of continued fin and tail rot which may have resulted in reduced feeding and therefore bias the results. For individual Diet results see Appendices 1 and 2.

Intestinal contents were difficult to analyze because the initial dissections represented the residue of meals eaten prior to the final feeding. The diets will affect the amount of intestinal contents found in the early dissections and the time at which the final meal was fully represented in the intestine was hard to determine.

The fish fed the pectin diet (Diet 3) had the lowest feed consumption indicating that the fish preferred the other experimental diets to the pectin diet. This may have been due to a texture or flavour caused by the pectin.

The cellulose diet (Diet 4) resulted in poorer feed conversion (feed/weight gain), than did the control or basal diet (Diet 1) or the high lipid diet (Diet 2).

There was no significant difference between the basal diet (Diet 1) and the high lipid diet (Diet 2) with regard to the amount of feed eaten and the weight gain.

The only significant difference found for evacuation rates from the stomach was between the basal diet (Diet 1) and the cellulose diet (Diet 4). The quantity of feed in the stomach was greater for Diet 4 at 1 hour than for all other diets. The cellulose diet (Diet 4) and the high lipid diet (Diet 2) both evacuate to 50% of the initial content by 8.25 hours and the control basal diet (Diet 1) took 9 hours. The pectin diet (Diet 3) appeared to take the longest to evacuate stomach contents to 50% of the initial fill, taking 15.75 hours. The cellulose diet (Diet 4) had the fastest rate of evacuation, evacuating at 0.248 g/h, whereas the pectin diet (Diet 3) was the slowest at 0.098 g/h. There was no significant difference between diets and passage time for the intestinal contents.

The expected hypothesis that high lipid diets would have decreased gastric evacuation rates in fish was suggested by Windell et al. (1969). High lipid diets have decreased gastric evacuation rates in other species. In this experiment, the high lipid diet (Diet 2) appeared to have evacuated to 50% of the initial fill in the approximately the same length of time as the control basal diet (Diet 1) and the cellulose diet (Diet 4).

Fish increase their food intake by increasing meal size to partly offset decreased energy supply (Grove et al., 1985). The fish ate more of the cellulose diet (Diet 4) than of the other diets. There also was a greater quantity eaten in one feeding. These results would agree with the research quoted by Grove et al.

(1985).

Fish fed diets containing components of low digestibility have decreased evacuation rates according to Fange and Grove (1979). On the other hand Jobling (1981) reported that if diets are diluted with inert material, they will be evacuated more rapidly, according to which, the diet with cellulose (Diet 4), in the present experiment should have evacuated more slowly. The pectin diet (Diet 3) could be expected to evacuate more rapidly than Diet 1, the basal control diet. However, there was no significant difference noted between these diets. Diet 3 took longer (15.75 hours) to evacuate to 50% of the initial fill content, than did either the control diet (Diet 1), the high lipid diet (Diet 2) or the cellulose diet (Diet 4). The cellulose diet was evacuated at the fastest rate, 0.248 g/h while the pectin diet was evacuated at 0.098 g/h.

Both Diets 3 and 4 had fibre additions. Fibre can be divided into viscous or water-soluble polysaccharides such as guar gum, pectin, and carboxymethyl cellulose and into non-viscous or water insoluble polysaccharides such as alpha-cellulose. As stated previously, the addition of fibre has an effect on the movement of nutrients along the gastrointestinal tract, likely influencing the nutrient absorption (Shiau et al., 1988). The addition of fibre to the diet has been shown to interfere with the absorption of many nutrients such as bivalent metals and with other nutrients such as fats and amino acids by decreasing their absorption (Southgate and Durin, 1970). Both dietary fibre and fibre isolates have been found to sequester bile salts and bind fatty acids, thereby decreasing the availability of cholesterol and by-products of triglyceride digestion (Vahouny et al., 1981). Barrow pigs fed semi-purified diets containing 17% crude protein had one of the diets substituted with a diet in which 7.5% of the cornstarch was replaced with an equal portion of pectin. This resulted in the digestibility of protein being 21.4% higher in the diets where pectin was not added (Anonymous, 1992). The data for the passage rates for experimental diets with fibre additions were conflicting. The water-soluble fibre pectin slowed the rate of passage and the water insoluble fibre cellulose had a higher evacuation rate to 12 hours than the other experimental diets. The quantity of water within the stomach contents could be due to the pectin interacting with the water, resulting in a high water content of the stomach contents for the pectin diet.

When wet weights were used, meal size had a marked effect on evacuation rates compared to when dry weights of stomach contents (Elliot, 1991). Wet weight measurements appeared to have a much higher evacuation rate than dry weights, suggesting that the moisture of the bolus affected evacuation measurements (Elliot, 1991).

However, the present experiment findings could be suspect due to the large variation in fish size and the poor health of the fish resulting in a high variation of results for the experiment.

3.0 Experiment 2

3.1 Introduction

In experiment 1, when wet weights of stomach and intestinal contents were used to determine passage times, the results were highly variable; therefore, for experiment 2, both wet weights and dry weights of stomach and intestinal contents were calculated for a more accurate estimate of evacuation rates. In Experiment 2, both a fresh water location and a salt water location were used. The fish were four different diets in the fresh water location; a control basal diet (Diet 1); a diet with gelatin added (Diet 2); a diet with a high lipid level (Diet 3); and a diet with a cellulose addition coupled with a lipid level of 19.9% (Diet 4). In the salt water location only Diets 1, 3 and 4 were used due to restricted space.

Gastric evacuation rates were compared for the different diets at both locations. Also, the water content of the ingesta in the stomachs were determined and compared between the locations.

3.2 Materials and Methods

This experiment consisted of two locations being compared simultaneously. There were 24 fresh water tanks and 18 sea water tanks used. A continuous flow of water was used in each facility to maintain the oxygen levels. Air stones were necessary at the fresh water facility to maintain oxygen levels at 11 to 12.2 ppm. Temperatures at the fresh water facility were between 8.2 and 9.5 °C with an average of 8.57 °C. The salt water facility had water temperatures which ranged from 8.5 to 8.7 °C with an average of 8.52 °C. Oxygen levels at the salt water facility were between 8 and 11 ppm.

3.2.2 Experimental Fish

Rainbow trout were transported to the fresh water facility using a transport tank supplied with oxygen. They were placed into tanks in the fresh water facility to be sorted. All fish were weighed and sorted; fish outside the average fish size or with abnormalities were removed to spare tanks. The 424 fish remaining weighed between 134 grams and 247 grams. The fish were then distributed randomly, 10 fish per tank resulting in six replicates for each of the dietary treatments. There were 240 fish at the fresh water facility and 184 fish at the salt water facility. In fresh water there was 183.15 grams mean weight of fish per tank in 150 litres of water to equal a stocking density of 1.22 g/l. In salt water, there was 178.96 grams mean weight of fish per tank in 150 litre tanks for a density of 1.19 g/l.

The fish allocated to the salt water facility were transported in a fish transport tank with oxygen supplied. A small amount of Marinil was used to tranquilize the fish to reduce the stress of transport. The transport took 40 minutes and upon arrival at the salt water facility the fish were introduced immediately into salt water tanks.

3.2.3 Diet Preparation and Composition

The diets were formulated in the laboratory of the Department of Animal Science of The University of British Columbia (Table 7). Vitamin and mineral premixes were compiled in the required amounts before adding to the diets (Table 8). After pelleting, herring oil was sprayed on to coat the diets to bring the diets up to the desired lipid levels.

3.2.4 Experimental Protocol

The fish were fed on a commercial diet for the first week. During four days prior to the experiment increasing amounts of the experimental diets were introduced until the fourth day when the experimental diets were 100% of the diets fed.

The fish in both facilities were fed to satiation once daily in the morning. The fish were fed the diets for 14 days. On the 14th day, the fish were first fed, then two fish from each tank at each time period were randomly selected, placed in a Marinil bath to tranquilize them, thus reducing the chance of stress induced vomiting. The fish were then placed in an anesthetic bath to immobilize them (Marinil bath mixture and anesthetic mixture described in Appendix 13). They were then removed from the bath, weighed and instantly frozen whole in liquid nitrogen. They were labelled, bagged and stored in a freezer for later analysis. This procedure was carried out at time intervals post-feeding. The time intervals selected were 1, 6, 12, 18 and 24 hours.

When analyzing the stomach and intestinal contents of the test fish, the frozen fish were slightly thawed using a microwave oven, for 2 to 4 minutes, depending on the size of the fish. Thawing was just sufficient to allow a scalpel or scissors to be inserted into the rectal passage of the fish. The body wall was then cut to allow access to the digestive tract which was still frozen.

TABLE 7: DIET FORMULATION FOR EXPERIMENT 2

BASAL DIET

INGREDIENTS	g/kg DIET	g PROTEIN/ kg DIET	g LIPID/ kg DIET	ADDED LATER g*
Herring Meal	263.88	175.24	30.35	
Corn Gluten Meal	141.29	85.85	0.90	
Soy Protein	102.46	86.80	0.41	
Ground Wheat	341.37	50.39	7.58	
Herring Oil	81.00		81.00	37.34
Premix	40.00			
Calcium Lignose Sulphonate	30.00			
TOTAL	1000.00	398.75	120.24	

DIET 2

INGREDIENTS	g /kg DIET	g PROTEIN/ kg DIET	g LIPID/ kg DIET	ADDED LATER g*
Herring Meal	231.89	154.00	26.67	
Corn Gluten Meal	124.07	75.39	0.79	
Soy Protein	90.22	76.44	0.36	
Ground Wheat	298.26	44.02	6.62	
Herring Oil	85.55		85.55	33.54
Premix	40.00			
Calcium Lignose Sulphonate	30.00			
Gelatin	100.00	100.00		
TOTAL	1000.00	449.85	119.99	

*= oil sprayed on later to coat the pellets

TABLE 7: CONTINUED DIET FORMULATION FOR EXPERIMENT 2

DIET 3

INGREDIENTS	g/kg DIET	g PROTEIN/ kg DIET	g LIPID/ kg DIET	ADDED LATER g*
Herring Meal	231.89	154.00	26.67	
Corn Gluten Meal	124.07	75.39	0.79	
Soy Protein	90.22	76.44	0.36	
Ground Wheat	298.26	44.02	6.62	
Herring Oil	85.55		85.55	128.35
Premix	40.00			
Calcium Lignose Sulphonate	30.00			
Herring Oil	100.00		100.00	
TOTAL	1000.00	349.85	219.99	

DIET 4

INGREDIENTS	g/kg DIET	g PROTEIN/ kg DIET	g LIPID/ kg DIET	ADDED LATER g*
Herring Meal	208.70	114.31	24.00	
Corn Gluten Meal	111.67	55.96	0.71	
Soy Protein	81.20	56.74	0.32	
Ground Wheat	268.43	32.68	5.96	
Herring Oil	77.00		77.00	106.7
Premix	36.00			
Calcium Lignose Sulphonate	27.00			
Herring Oil	90.00		90.00	
Alpha-cellulose	100.00			
TOTAL	1000.00	259.68	197.99	

*=oil sprayed on later to coat the pellets

All moisture levels were calculated and moisture levels of the diet brought up to 18% moisture. The portion of the oil added later was reserved from the quantity of the diet to sprayed on to coat the pellets. Diets 1, 3, and 4 were made in quantities of 15 kg. Diet 2 was made to 7.5 kg.

TABLE 8: Vitamin and Mineral Premix for Experiment 2.

Vitamin	mg/kg fed
Thiamine HCl	60.00
Riboflavin	100.00
Niacin	400.00
Biotin	5.00
Folic Acid	25.00
Pyridoxine.HCl	50.00
Vit. B_{12} - Cyanocobalamine	0.10
D-Calcium Pantothenate	200.00
Vit. C - Ascorbic Acid	1500.00
Choline Chloride (60%)	4000.00
Inositol	2000.00
Vit. A - Retinyl Palmitate	10000.00
Vit. D_3 - Cholecalciferol	300.00
Vit. E - DL-α-tocopherol Acetate	1000.00
Vit. K - Menadione	30.00

Minerals	mg/kg fed
Magnesium as $MgSO_4$	380.00
Manganese as $MnSO_4.5H_2O$ (75%)	30.00
Zinc as ZnO	70.00
Iron as $FeSO_4.7H_2O$	85.00
Copper as $CuSO_4.5H_2O$	2.00
Cobalt as $CoCl.6H_2O$	0.003
Iodine as KIO_3	5.00
Fluorine as NaF	4.50
Selenium as $Na_2SeO_3.5H_2O$	0.10
Phosphorus(as Potassium Phosphate)	2070.00

The stomach wall peeled away from the bolus cleanly, allowing the bolus to be weighed in pre-dried weigh dishes. The contents were then dried to a constant weight in a drying oven at 80 °C for 72 hours. The same procedure was followed for the intestinal contents. The pyloric caeca were squeezed out into weighing dishes and all intestinal contents removed via dissection, weighed and then dried in a hot-air drying ovens for 72 hours.

Analyses of the data was done using Lotus and SYSTAT. Statistical analyses included Analysis of Variance using SYSTAT (Wilkinson, 1989). Differences between means were tested at $P \leq 0.05$, using Tukey's multiple range test. Analysis of Variance was carried out to determine if there were tank effects. Since none was shown, the subsequent analyses were carried out on the pooled data.

3.3 Results

3.3.1 Fresh Water Facility

3.3.1.1 Feed Consumption and Weight Gain

There were no significant differences in the amounts of feed consumed of the different test diets. There were significant differences in the amounts of weight gained per fish for the different dietary treatments. There was significantly more weight gained by the fish fed the high lipid diet (Diet 3) than either the basal (Diet 1) or the gelatin (Diet 2) diets. Although there was a higher weight gain for the high lipid diet (Diet 3) than for the cellulose/high lipid diet (Diet 4), the difference was not significant (Table 9).

TABLE 9: RELATIONSHIP OF FEED CONSUMPTION TO BODY WEIGHT GAIN IN RAINBOW TROUT REARED ON 4 DIFFERENT DIETS IN FRESH WATER, EXPERIMENT 2.

DIETS	FISH WEIGHT GAIN (COVARIATE OF AMOUNT OF DIET EATEN) MEAN (g)	FEED (AS FED) / WEIGHT GAIN
DIET 1 BASAL	$38.0^{A} \pm 10.1$	$0.92^{A*} \pm 0.16$
DIET 2 GELATIN	$38.9^{A} \pm 8.5$	$0.92^{A*} \pm 0.16$
DIET 3 HIGH LIPID	$49.2^{B} \pm 8.3$	$0.70^{B*} \pm 0.06$
DIET 4 CELLULOSE/ HIGH LIPID	$40.7^{AB} \pm 11.3$	$0.85^{AB*} \pm 0.00$
SAMPLE NUMBERS	N=24	N=24

NB: * = OVERALL SIGNIFICANCE WAS BELOW 5% BUT THE DIFFERENCE BETWEEN DIETS WAS NOT SIGNIFICANT AT $P \leq 0.05$ BUT WAS AT $P \leq 0.10$. Mean values without a common superscript letter were significantly ($P \leq 0.05$) different according to Tukey's test.

There were no significant differences between the weights of the fish for each diet before the start of the experiment. Table 10 provides all feed and weight information.

TABLE 10: EXPERIMENT 2, FEED CONSUMPTION AND WEIGHT GAINS OF RAINBOW TROUT REARED IN FRESH WATER (10 FISH/TANK)

DIET	TANK #	FEED EATEN (g)	FEED /FISH (g)	MEAN INITIAL FISH WEIGHT (g)	MEAN FINAL FISH WEIGHT (g)	WEIGHT GAIN (g)	FEED/ WEIGHT GAIN
BASAL 1	14	333.0	33.3	174.5	220.3	45.8	0.73
1	23	264.8	26.5	179	215.0	36.0	0.74
1	20	235.2	23.5	184.5	212.3	27.8	0.85
1	3	449.7	45.0	192.9	238.3	45.4	0.99
1	4	544.8	54.5	180.8	231.1	50.3	1.08
1	11	260.4	26.0	177.3	200.0	22.7	1.15
MEAN SD		348.0 113.0	34.8 11.3	181.5 5.9	219.5 12.5	38.0 10.1	0.92 0.16
GELATIN 2	10	373.2	37.3	183.4	229.6	46.2	0.81
2	2	350.0	35.0	183.8	227.1	43.3	0.81
2	8	351.0	35.1	167.7	210.1	42.4	0.83
2	1	396.9	39.7	176.4	223.6	47.2	0.84
2	13	256.4	25.6	195.6	221.1	25.5	1.01
2	16	354.4	35.4	170.3	199.0	28.7	1.23
MEAN SD		347.0 43.7	34.7 4.4	179.5 9.4	218.4 10.6	38.9 8.5	0.92 0.16
HIGH LIPID 3	9	213.1	21.3	174.8	209.7	34.9	0.61
3	19	305.5	30.5	199.6	246.5	46.9	0.65
3	18	312.9	31.3	178.1	222.6	44.5	0.70
3	22	390.3	39.0	186.4	239.5	53.1	0.73
3	6	412.0	41.2	194.7	250.0	55.3	0.75
3	5	466.5	46.6	197.0	257.5	60.5	0.77
MEAN SD		350.0 82.8	35.0 8.3	188.4 9.4	237.6 16.5	49.2 8.3	0.70 0.06
CELLULOSE/HIGH LIPID 4	21	291.7	29.2	194.7	233.5	38.8	0.75
4	0	327.0	32.7	170.6	213.6	43.0	0.76
4	15	510.3	51.0	175.6	238.2	62.6	0.82
4	7	291.3	29.1	182.0	217.6	35.6	0.82
4	12	225.7	22.6	189.4	214.4	25.0	0.90
4	17	421.2	42.1	186.6	225.7	39.1	1.08
MEAN SD		344.5 94.4	34.4 9.4	183.1 8.2	223.8 9.4	40.7 11.3	0.85 0.11

3.3.1.2 Evacuation of the Stomach Contents Over Time

The data from the stomach contents as a percentage of fish weight for the fish fed on the different diets are summarized in Table 11.

TABLE 11: STOMACH CONTENTS OF FISH GROWN IN FRESH WATER (Average Dry Weights of stomach contents As % body Weight) AT DIFFERENT TIMES POST PRANDIAL

HOURS POST FEEDING		DIET 1 CONTROL	DIET 2 GELATIN	DIET 3 HIGH LIPID	DIET 4 CELLULOSE
1	MEAN	2.07	2.32	2.28	2.71
	SD	0.70	0.40	0.93	0.49
	N	(9)	(9)	(8)	(7)
6	MEAN	1.82^{A}	1.89^{AB}	2.33^{B}	2.45^{B}
	SD	0.67	0.47	0.69	0.45
	N	(9)	(9)	(9)	(8)
12	MEAN	1.48	1.67	1.68	1.51
	SD	0.69	0.76	0.58	0.48
	N	(11)	(9)	(7)	(10)
18	MEAN	1.12	1.48	1.50	1.85
	SD	0.61	0.51	0.80	1.04
	N	(8)	(10)	(11)	(11)
24	MEAN	0.78	0.94	1.09	1.12
	SD	0.64	0.53	0.58	0.43
	N	(9)	(10)	(11)	(10)

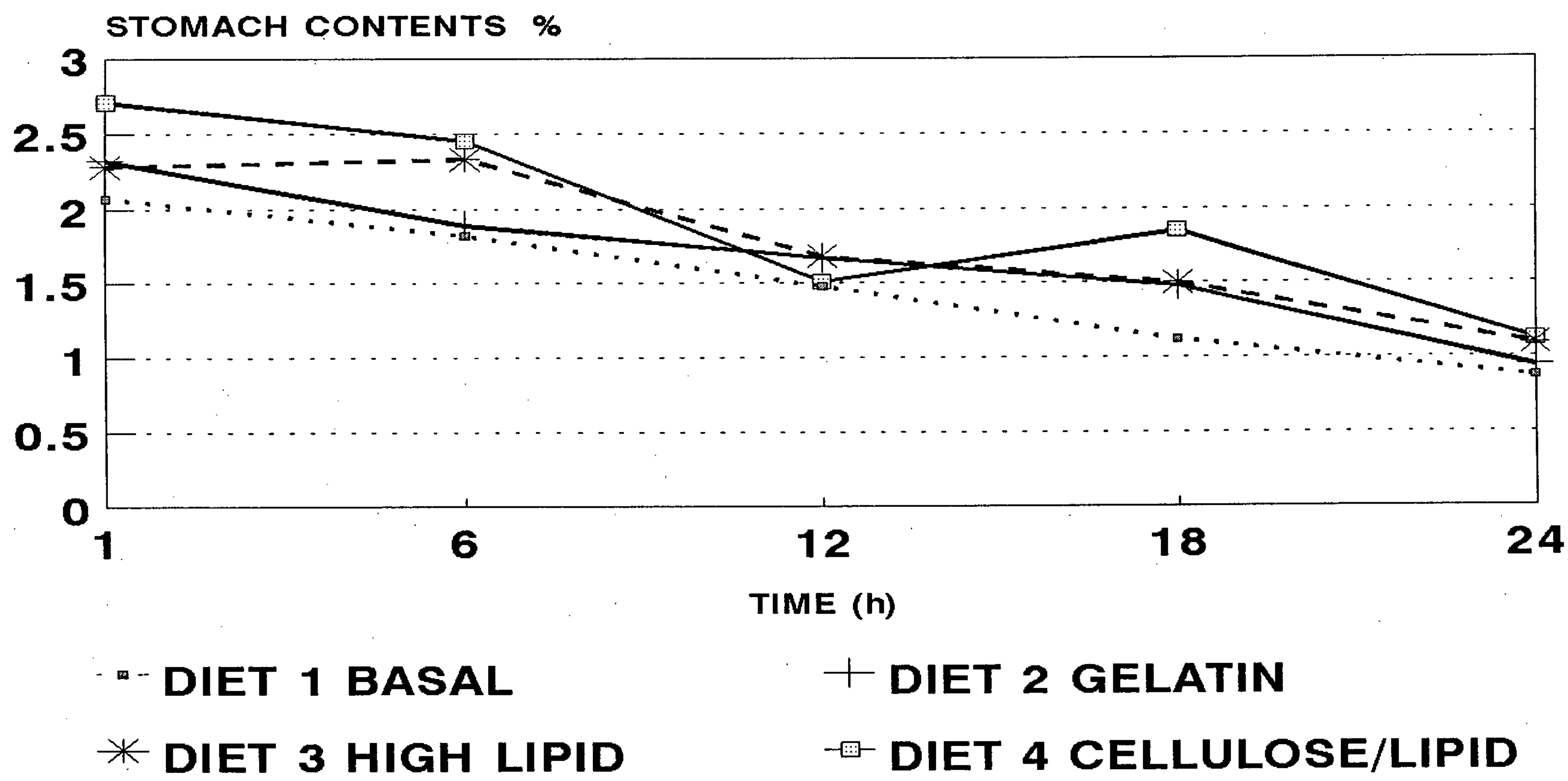
NB 1: When both the stomach and the intestine were empty of contents, it was assumed that the fish did not eat and therefore it was not included in the data. After 12 hours, if the intestine had contents, the stomach contents were included in the mean even if the stomach was empty. Stomach contents were recorded as zero.
NB 2: Mean values with unlike superscript letters were significantly ($P \leq 0.05$) different according to Tukey's test.

There was a significant difference (P=0.014, N=39) between the quantity of contents at 6 hour. Using Tukey's mean comparison there were significant differences between the control diet (Diet 1) and the high lipid diet (Diet 3) at P=0.049; and, between the control diet (Diet 1) and the cellulose/lipid diet (Diet 4) at P=0.027. Fish fed the high lipid diet (Diet 3) and the cellulose/lipid diet (Diet 4) had larger quantities of feed still present in the stomach than did the control diet (Diet 1) or the gelatin diet (Diet 2) by 24 hours.

In Figure 3, the slopes of the lines describing the weight of the stomach contents were visually compared. The cellulose diet (Diet 4) had a steeper slope from 1 hour to 12 hours than the other three diets. For Diet 4, a larger quantity of the diet had been consumed as evidenced by the weight of stomach contents after 1 hour, than was the case with the other diets. By 12 hours, the stomach contents in fish fed Diet 4 had dropped to the same quantity as was the case with the control diet (Diet 1) and was less than in the fish fed the high lipid or gelatin diets. It was, therefore, apparent that gastric evacuation for Diet 4 was faster to 12 hours than for the other three experimental diets. In comparing the quantity of the stomach contents from 1 to 12 hours for the different diets, the basal diet (Diet 1) evacuated at 0.054 g/h, the gelatin diet (Diet 2) at 0.59 g/h, the high lipid diet (Diet 3) at 0.055 g/h and the cellulose/high lipid diet (Diet 4) at 0.109 g/h. The cellulose/high lipid diet evacuated at a faster rate than did the other experimental diets. After 12 hours the variation in data for Diets 3 and 4 was high making any further analysis of the curves difficult.

An estimate of the time it takes to reach 50% evacuation was carried out on the graph in Figure 3. Using the dry weights of the

FIGURE 3: STOMACH CONTENTS OF RAINBOW TROUT REARED ON 4 DIFFERENT DIETS IN FRESH WATER



Experiment 2
Weight of stomach contents as a percent of body weight

stomach contents, evacuation times to reach 50% were estimated as follows: the control diet (Diet 1) approximately 20 hours; the gelatine diet (Diet 2), 22.5 hours; the high lipid diet (Diet 3) $\geq$ 24 hours; and, the cellulose/lipid diet (Diet 4), 23 hours.

3.3.1.3 Evacuation of Intestinal Contents Over Time

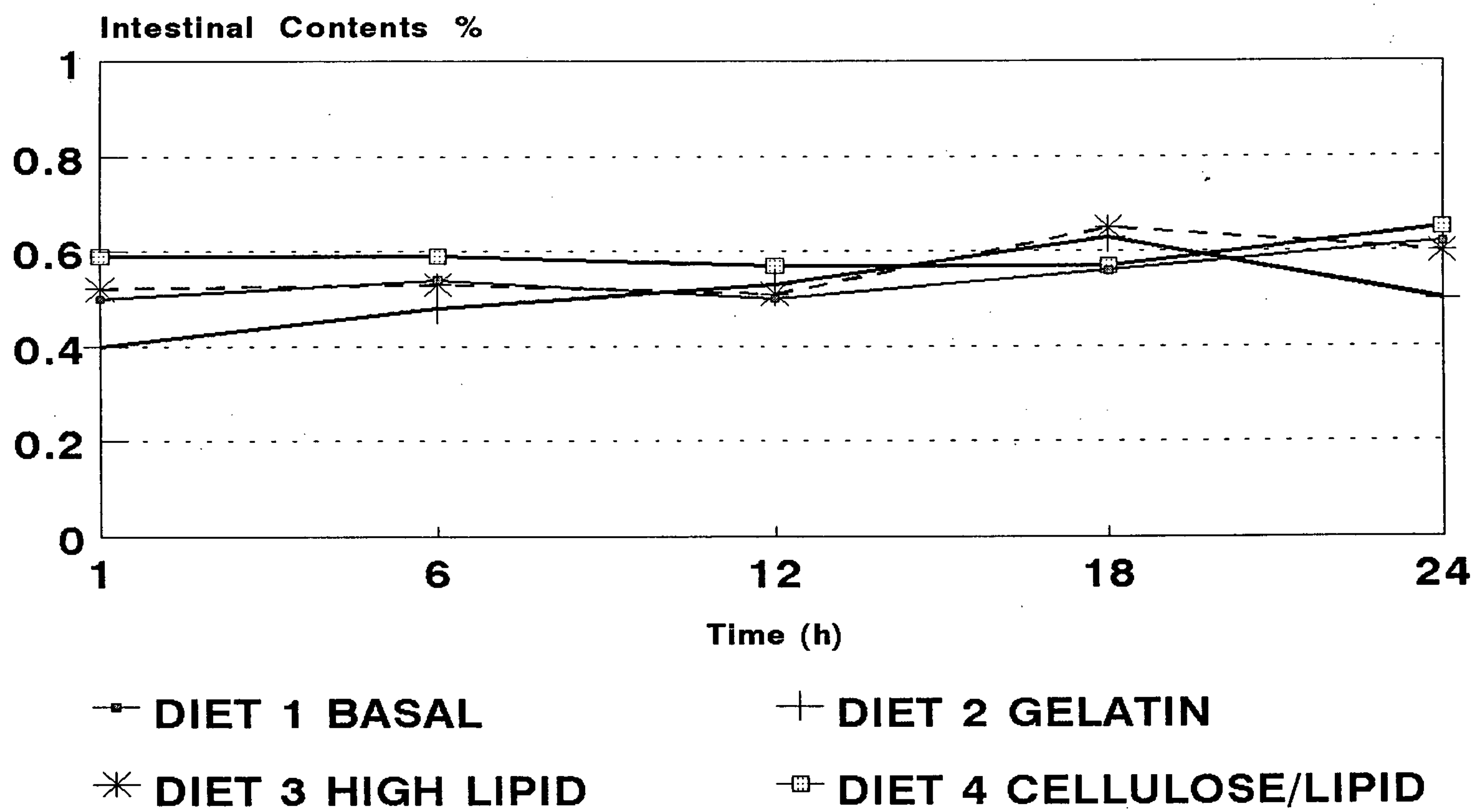
Table 12 presents the data of the dry weight intestinal contents of the fish in fresh water over the time series. At 1 hour there was a significant difference between the diets (P=0.030, N=33). Using Tukey's test for mean comparison, there was a significant difference between the gelatin diet (Diet 2) and the cellulose/high lipid diet (Diet 4) at P=0.020. There was also significant difference at 18 hours (P=0.008, N=44). There was a significant difference between the basal diet (Diet 1) and the high lipid diet (Diet 3), P=0.006. There were no other significant differences between intestinal contents over time. Figure 4 graphically presents the results demonstrating that the differences were not clearly defined. As stated previously, intestinal contents were difficult to analyze because the initial dissections represented the residual of meals eaten prior to the final feeding.

TABLE 12: INTESTINAL CONTENTS OF FISH GROWN IN FRESH WATER (Average Dry Weights of intestinal contents As % body Weight) AT DIFFERENT TIMES POST PRANDIAL

HOURS POST FEEDING		DIET 1 CONTROL	DIET 2 GELATIN	DIET 3 HIGH LIPID	DIET 4 CELLULOSE
1	MEAN	0.50^{AB}	0.40^{A}	0.52^{AB}	0.59^{B}
	SD	0.10	0.07	0.16	0.11
	N	(9)	(9)	(8)	(7)
6	MEAN	0.54	0.48	0.53	0.59
	SD	0.09	0.10	0.10	0.05
	N	(9)	(9)	(9)	(8)
12	MEAN	0.50	0.53	0.51	0.57
	SD	0.15	0.17	0.16	0.17
	N	(11)	(9)	(7)	(10)
18	MEAN	0.56^{A}	0.63^{AB}	0.65^{B}	0.57^{AB}
	SD	0.23	0.05	0.12	0.14
	N	(8)	(10)	(11)	(11)
24	MEAN	0.62	0.50	0.60	0.65
	SD	0.19	0.14	0.10	0.13
	N	(9)	(10)	(11)	(10)

NB 1: When both the stomach and the intestine were empty of contents, it was assumed that the fish did not eat and therefore it was not included in the data. After 12 hours, if the intestine had contents, the stomach contents were included in the mean even if the stomach was empty. Stomach contents were recorded as zero.
NB 2: Mean values with unlike superscript letters were significantly ($P \leq 0.05$) different according to Tukey's test.

FIGURE 4: INTESTINAL CONTENTS OF RAINBOW TROUT REARED ON 4 DIFFERENT DIETS IN FRESH WATER



Experiment 2
Weight of Intestinal Contents as a percent of body weight.

3.3.2 Salt Water Facility

3.3.2.1 Feed Consumption and Weight Gain

There was no significant difference in the amount of the various diets consumed. There was a significant difference in the amount of weight the fish gained at $P \leq 0.10$. There was significantly more weight gained by fish fed the control diet (Diet 1) than for the high lipid diet (Diet 3). There was no significant difference between the cellulose/high lipid diet (Diet 4) and Diets 1 or 3. There was a significant difference at $P \leq 0.10$ between weight gains when a COVARIATE of amount of diet eaten was considered between Diets 1 and 2 as well.

TABLE 13: RELATIONSHIP OF FEED CONSUMPTION TO BODY WEIGHT GAIN IN RAINBOW TROUT REARED ON 3 DIFFERENT DIETS IN SALT WATER, EXPERIMENT 2

DIETS	FISH WEIGHT GAIN MEAN (g)	FEED (AS FED) / WEIGHT GAIN
DIET 1 BASAL	$37.1^{A} \pm 4.7$	0.84 ± 0.07
DIET 3 HIGH LIPID	$30.7^{B} \pm 2.3$	0.94 ± 0.09
DIET 4 CELLULOSE/ HIGH LIPID	$33.2^{AB} \pm 4.2$	1.01 ± 0.22
OVERALL	P=0.056*	
SAMPLE NUMBERS	N=18	N=18

NB: Values with unlike superscript letters were significantly ($P \leq 0.10$) different according to Tukey's test but not significant at $P \leq 0.05$.

There were no significant differences between the weights of the fish for each diet before the start of the experiment. Table 14 provides all feed and weight information.

TABLE 14: EXPERIMENT 2, FEED CONSUMPTION AND WEIGHT GAINS OF RAINBOW TROUT REARED IN SALT WATER (10 FISH/TANK)

DIET	TANK	FEED EATEN (g)	FEED /FISH (g)	MEAN INITIAL FISH WEIGHT (g)	MEAN FINAL FISH WEIGHT (g)	WEIGHT GAIN (g)	FEED/ WEIGHT GAIN
BASAL 1	B	291.0	29.1	178.7	216.3	37.6	0.77
1	I	344.0	34.4	184.5	228.4	43.9	0.78
1	L	283.0	28.3	177.6	211.3	33.7	0.84
1	D	361.0	32.8	198.4	241.1	42.6	0.77
1	O	291.0	29.1	170.6	203.0	32.4	0.90
1	P	308.0	30.8	174.5	207.0	32.5	0.95
MEAN SD		313.0 29.3	30.7 2.2	180.7 9.0	217.8 13.1	37.1 4.7	0.84 0.07
HIGH LIPID 3	G	268.0	26.8	159.6	194.0	34.4	0.78
3	J	298.0	29.8	175.7	208.1	32.4	0.92
3	R	278.0	27.8	172.2	201.4	29.2	0.95
3	C	281.0	28.1	187.7	215.5	27.8	1.01
3	Q	322.0	29.3	167.3	198.9	31.6	0.93
3	M	307.0	30.7	180.1	209.0	28.9	1.06
MEAN SD		292.3 18.5	28.7 1.3	173.8 9.0	204.5 7.1	30.7 2.3	0.94 0.09
CELLULOSE/HIGH LIPID 4	N	291.0	29.1	182.8	224.7	41.9	0.69
4	A	301.0	27.4	180.4	214.0	33.6	0.81
4	E	307.0	27.9	176.8	207.4	30.6	0.91
4	K	351.0	35.1	183.8	214.1	30.3	1.16
4	H	345.0	34.5	178.3	207.9	29.6	1.17
4	F	441.0	44.1	192.2	225.5	33.2	1.33
MEAN SD		339.0 50.0	33.0 5.8	182.4 5.0	215.6 7.2	33.2 4.2	1.01 0.22

3.3.2.1 Evacuation of the Stomach Contents Over Time

Table 15 summarizes weights of the stomach contents at the various timed intervals for the salt water location. They are presented as a percentage of body weight for comparison purposes.

TABLE 15: STOMACH CONTENTS OF FISH GROWN IN SALT WATER (Average Dry Weights of stomach contents As % body Weight) AT DIFFERENT TIMES POST PRANDIAL

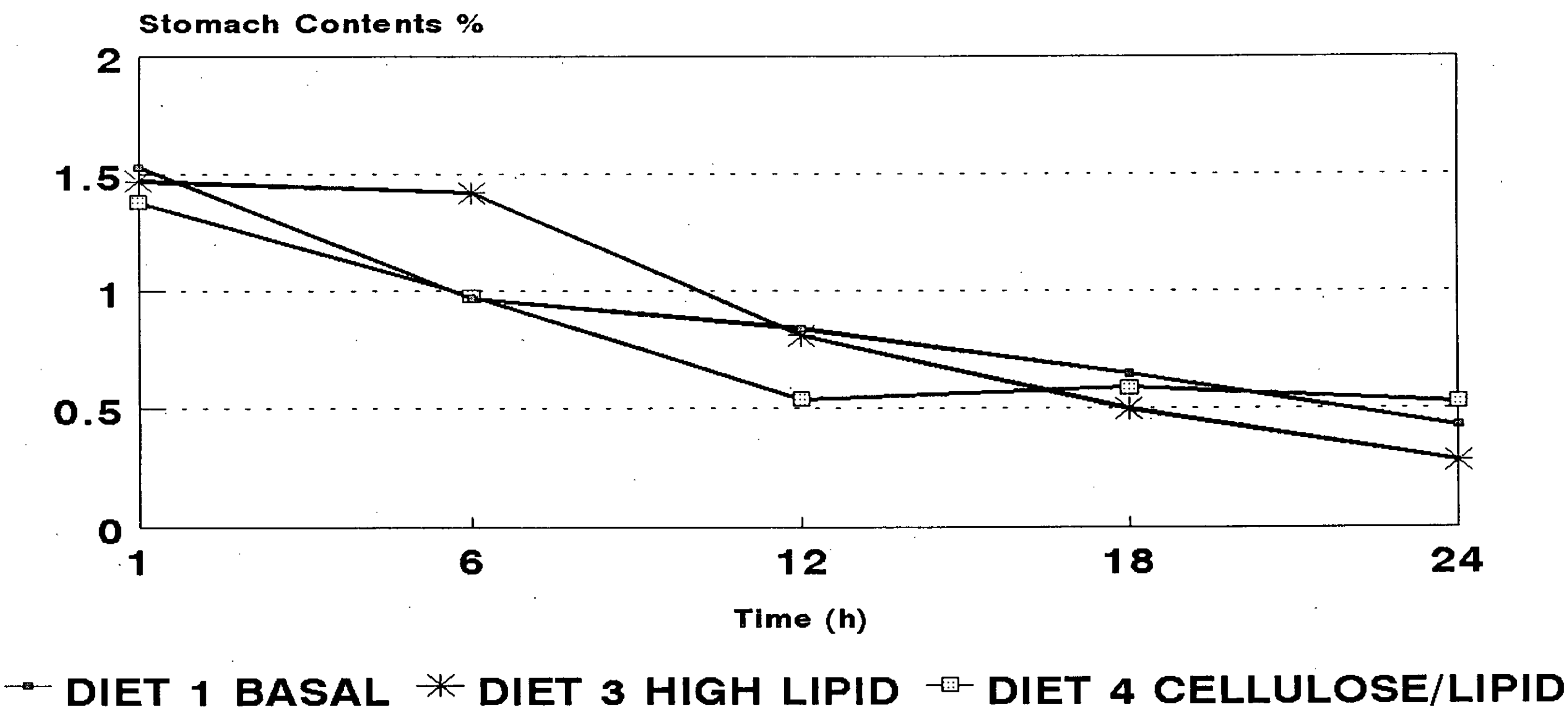
HOURS POST FEEDING		DIET 1 CONTROL (%)	DIET 3 HIGH LIPID (%)	DIET 4 CELLULOSE (%)
1	MEAN	1.53	1.47	1.38
	SD	0.43	0.64	0.61
	N	(12)	(12)	(12)
6	MEAN	0.97	1.42	0.98
	SD	0.43	0.62	0.52
	N	(12)	(11)	(12)
12	MEAN	0.84	0.81	0.54
	SD	0.39	0.52	0.34
	N	(12)	(11)	(12)
18	MEAN	0.65	0.50	0.59
	SD	0.28	0.41	0.45
	N	(12)	(12)	(12)
24	MEAN	0.43^{AB}	0.28^{A}	0.53^{B}
	SD	0.33	0.18	0.30
	N	(12)	(12)	(10)

NB 1: When both the stomach and the intestine were empty of contents, it was assumed that the fish did not eat and therefore it was not included in the data. After 12 hours, if the intestine had contents, the stomach contents were included in the mean even if the stomach was empty. Stomach contents were recorded as zero.
NB 2: Mean values with unlike superscript letters were significantly ($P \leq 0.05$) different according to Tukey's test.

After 24 hours, there was a significant difference between diets in the weight of the stomach contents (P=0.048, N=34). Using Tukey's test for mean comparison, there was a significant difference between the high lipid diet (Diet 3) and the cellulose diet (Diet 4), P = 0.038; a higher quantity of Diet 4 remained in the stomach. There were no other significant differences between the diets for any other time period.

Figure 5, illustrates the rates of gastric evacuation of the fish in salt water fed the different diets. The control diet and the diet containing cellulose were similar in the rates at which they left the stomach. The high lipid diet (Diet 3) did not leave the stomach until after 6 hours. In comparing the quantity of stomach contents from 1 to 12 hours for the different diets, the basal diet (Diet 1) evacuated at 0.063 g/h, the high lipid diet (Diet 3) at 0.060 g/h and the cellulose/high lipid diet (Diet 4) at 0.076 g/h. This indicated that the cellulose/high lipid diet evacuated faster for the first 12 hours after feeding.

FIGURE 5: STOMACH CONTENTS OF RAINBOW TROUT REARED ON 3 DIFFERENT DIETS IN SALT WATER



Experiment 2
Weight of stomach contents as a percent of body weight.

The times to evacuate 50% of the stomach contents were also compared to determine if the cellulose/lipid diet did evacuate faster. According to figure 5, 50% of the cellulose/lipid diet (Diet 4) had left the stomach by 10.25 hours. This was faster than either the high lipid diet (Diet 3), at approximately 13.25 hours, or the control diet (Diet 1) at 14.25 hours.

3.3.2.2 Evacuation of Intestinal Contents Over Time

Table 16 presents the data of the dry weight intestinal contents of the fish in salt water over the time series. At 24 hours there was a significant difference between diets (P=0.015,N=34). Using Tukey's test for mean comparison, there was a significant difference between the control diet (Diet 1) and the cellulose/high lipid diet (Diet 4), P=0.070; and, between the high lipid diet (Diet 3) and the cellulose/high lipid diet (Diet 4) at P=0.018. There was no other significant difference between diets throughout the 24 hours.

TABLE 16: INTESTINAL CONTENTS OF FISH GROWN IN SALT WATER (Average Dry Weights of intestinal contents as % body Weight) At DIFFERENT TIMES POSTPRANDIAL

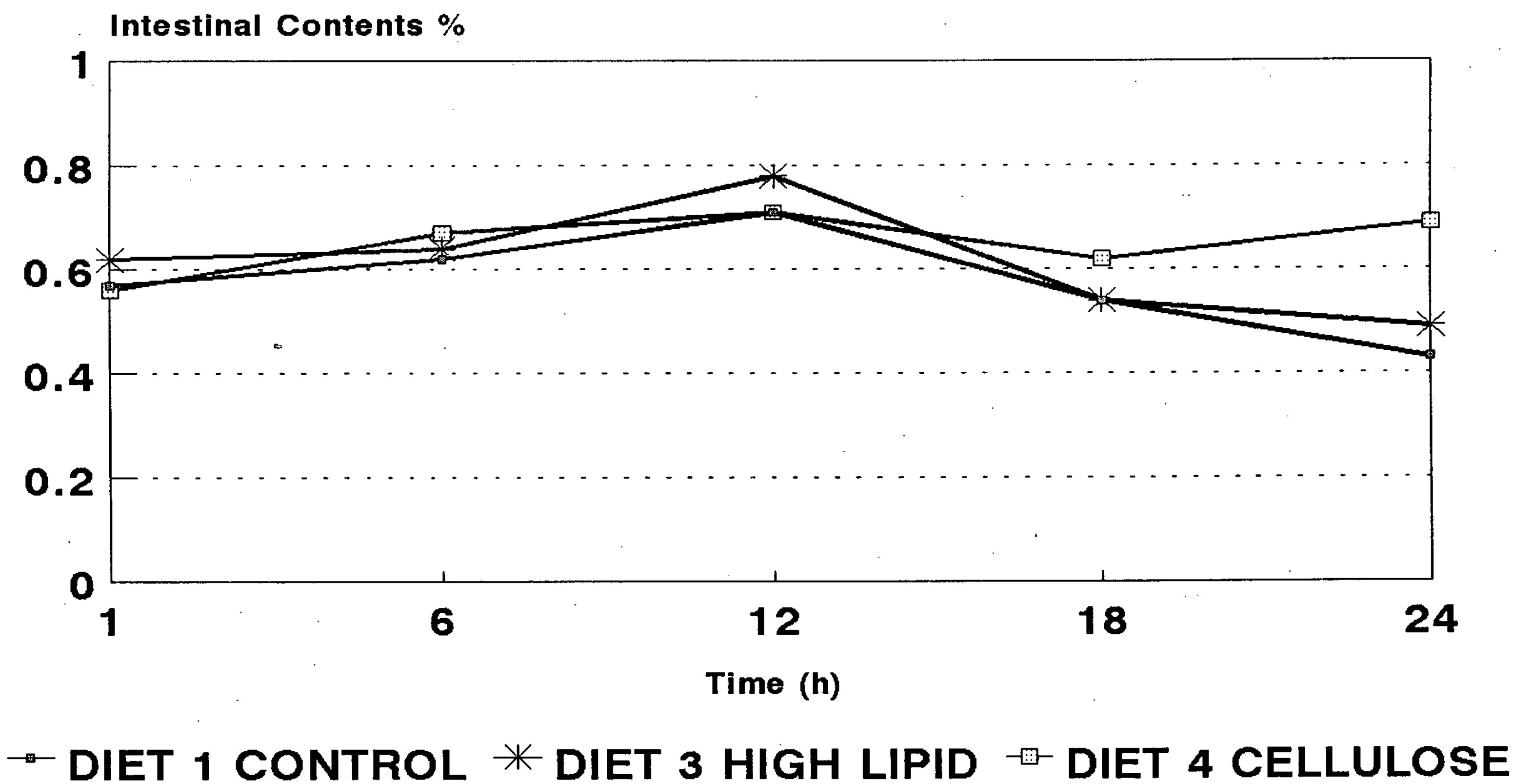
HOURS POST FEEDING		DIET 1 CONTROL %	DIET 3 HIGH LIPID %	DIET 4 CELLULOSE %
1	MEAN	0.57	0.62	0.56
	SD	0.14	0.10	0.21
	N	(12)	(12)	(12)
6	MEAN	0.62	0.64	0.67
	SD	0.20	0.18	0.26
	N	(12)	(11)	(12)
12	MEAN	0.71	0.78	0.71
	SD	0.23	0.35	0.24
	N	(12)	(11)	(12)
18	MEAN	0.54	0.54	0.62
	SD	0.20	0.25	0.20
	N	(12)	(12)	(12)
24	MEAN	0.43^{A}	0.49^{AB}	0.69^{B}
	SD	0.17	0.14	0.28
	N	(12)	(12)	(10)

NB 1: When both the stomach and the intestine were empty of contents, it was assumed that the fish did not eat and therefore it was not included in the data. After 12 hours, if the intestine had contents, the stomach contents were included in the mean even if the stomach was empty. Stomach contents were recorded as zero.
NB 2: Mean values with unlike superscript letters were significantly ($P \leq 0.05$) different according to Tukey's test.
NB 3: SD = 1 standard deviation N = sample size

Figure 6 illustrates the results graphically. The intestinal contents for the different diets were similar in quantity until 18 hours at which time the alpha-cellulose diet was retained in the intestine longer. The high lipid diet was also retained in the intestine longer than the control diet, but not significantly longer.

At 12 hours, the diets had increased to the maximum quantity within the intestine. This corresponds to the time it took for the stomach to evacuate approximately 50% of the initial fill. Therefore at 12 hours, 50% or more of the meal had passed through the stomach into the intestine. After 12 hours, the feed passed through the intestine at different rates depending on the ingredients of the diet.

FIGURE 6: INTESTINAL CONTENTS OF RAINBOW TROUT REARED ON 3 DIFFERENT DIETS IN SALT WATER



Experiment 2
Weight of intestinal contents as
a percent of body weight.

3.4 Comparison of Water content of Stomach Contents of Fish Reared in Fresh Water Versus Fish Reared in Salt Water

Tables 17 and 18 and Figure 7 compare the water content of the ingesta in the stomach of fish raised in fresh water to that of fish raised in salt water. Water content in the ingesta in the stomach of fish raised in salt water was consistently higher than that of the fish in fresh water.

In the fish raised in fresh water, there was a significant difference of water content in the stomach contents at 1 hour between all diets. At all other time periods there was no significant difference, $P \leq 0.05$.

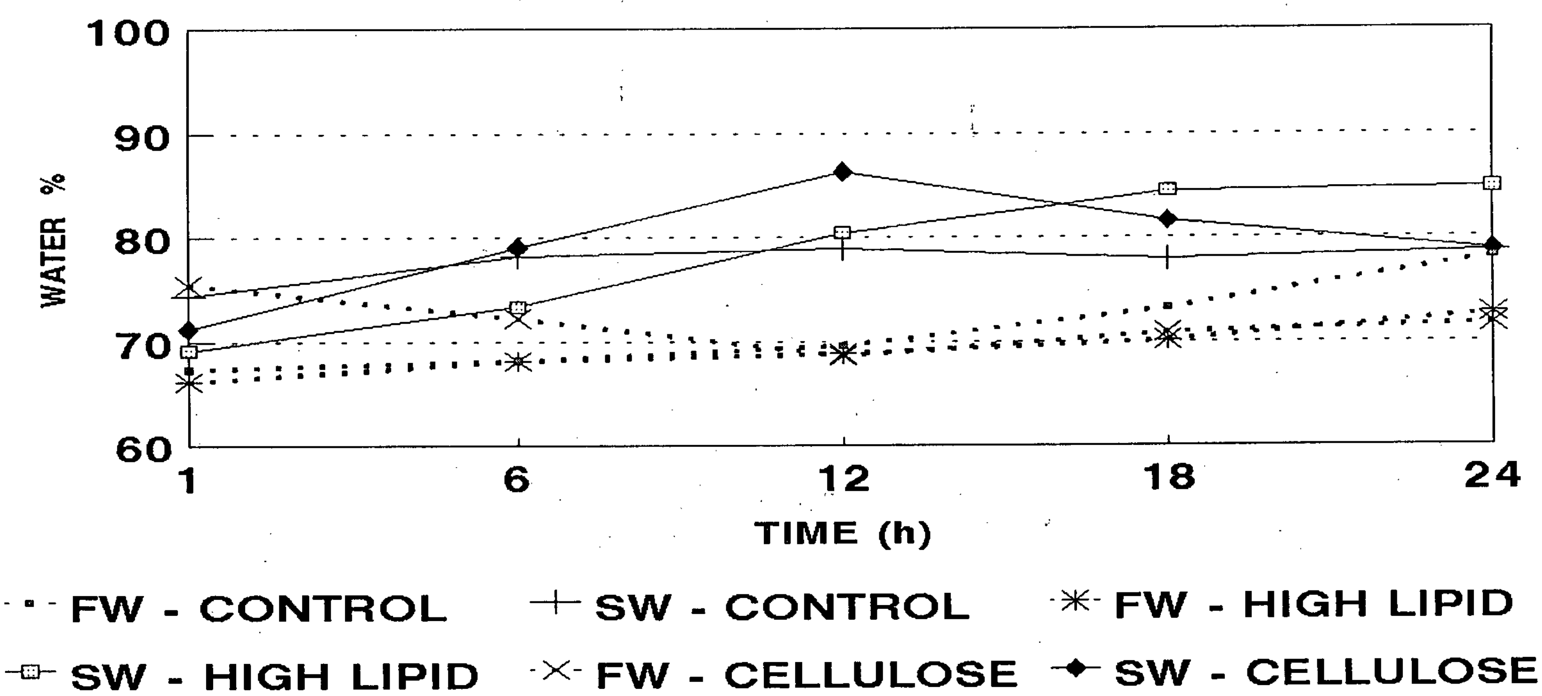
As seen in Table 17 and Figure 7, the cellulose diet (Diet 4) had a higher percentage of water than the other two diets at 1 hour. There was no significant difference between the other diets.

TABLE 17: THE WEIGHT AND % WATER CONTENT OF INGESTA IN THE STOMACH OF RAINBOW TROUT RAISED IN FRESH WATER, EXPERIMENT 2

TIME OF SAMPLING		DIET 1 CONTROL (g)	DIET 1 CONTROL (%)	DIET 3 HIGH LIPID (g)	DIET 3 HIGH LIPID (%)	DIET 4 CELLULOSE (g)	DIET 4 CELLULOSE (%)
1 HOUR	MEAN SD N	6.40 4.24 9	67.38[A]	6.85 4.86 8	66.19[A]	5.45 4.69 7	75.48[B]
6 HOURS	MEAN SD N	7.41 3.23 9	68.20	7.45 4.22 9	68.15	6.96 4.40 8	72.22
12 HOURS	MEAN SD N	7.86 3.28 11	69.62	10.27 3.36 7	68.85	8.04 1.67 10	68.64
18 HOURS	MEAN SD N	6.34 3.07 8	73.28	9.24 5.84 11	70.16	9.88 4.21 11	70.91
24 HOURS	MEAN SD N	6.18 3.34 9	78.18	6.35 2.50 11	72.75	6.19 1.62 10	71.79

NB 1: SD= STANDARD DEVIATION N= NUMBER OF FISH IN SAMPLE
NB 2: Mean values with unlike superscript letters were significantly ($P \leq 0.05$) different according to Tukey's test.

FIGURE 7: % WATER OF STOMACH CONTENTS OF RAINBOW TROUT REARED IN FRESH AND SALT WATER



Experiment 2
Diet 1 = Basal Diet 2 = Gelatin Diet 3= High Lipid Diet 4 = Cellulose/High Lipid
FW = Fresh Water SW = Salt Water

At the salt water location, there was no significant difference between water content of the ingesta in the stomachs of fish fed the experimental diets at 1 and 6 hours. At 12 hours there was a significant difference between the control diet (Diet 1) and the cellulose/high lipid diet (Diet 4); and between the lipid diet (Diet 3) and the cellulose/high lipid diet (Diet 4). The stomach contents of the fish that were fed the cellulose diet had an increasingly higher water content than the stomach contents of the fish fed the other two diets, until at 12 hours, the percentage of water in the stomach contents of fish that have eaten diet 4 has increased to be higher than water levels of stomach contents of fish fed Diets 1 or 3.

TABLE 18: THE WEIGHT AND % WATER CONTENT OF INGESTA IN THE STOMACH OF RAINBOW TROUT RAISED IN SALT WATER, EXPERIMENT 2

TIME OF SAMPLING		DIET 1 CONTROL (g)	DIET 1 CONTROL (%)	DIET 3 HIGH LIPID (g)	DIET 3 HIGH LIPID (%)	DIET 4 CELLULOSE (g)	DIET 4 CELLULOSE (g)
1 HOUR	MEAN SD N	7.90 3.24 12	74.38	5.70 3.31 12	69.16	7.27 2.93 12	71.27
6 HOURS	MEAN SD N	7.97 1.93 12	78.25	7.79 2.64 11	73.37	7.37 2.91 12	79.08
12 HOURS	MEAN SD N	6.24 1.97 12	78.93^{A}	6.86 2.80 11	80.46^{A}	7.65 3.46 12	86.34^{B}
18 HOURS	MEAN SD N	6.40 3.81 12	77.99	4.40 1.88 12	84.48	6.05 4.11 12	81.64
24 HOURS	MEAN SD N	3.58 2.31 12	78.73	3.59 2.59 12	84.82	4.57 1.73 10	78.88

NB 1: SD= STANDARD DEVIATION N= NUMBER OF FISH IN SAMPLE
NB 2: Mean values with unlike superscript letters were significantly ($P \leq 0.05$) different according to Tukey's test.

3.4 Discussion

Fish fed on the high lipid diet had a significantly better feed conversion rate than the fish fed on the other experimental diets. The duration of the experiment was short and therefore, further assessment of growth and feeding effects were not significant.

As seen by the stomach contents of the fish in fresh water, the high lipid diet (Diet 3) and cellulose/high lipid diet (Diet 4) took longer to leave the stomach than either the basal diet or gelatin diet. The cellulose/high lipid diet, however left the stomach at a faster rate for the first 12 hours after feeding. Similar results were seen in Experiment 1 with the cellulose diet evacuating more rapidly in the first 12 hours than did the other experimental diets. The intestinal contents of the fish in Experiment 2 showed a gradual increase until 18 hours, except in the fish fed the cellulose diet in which the amount of intestinal contents remained fairly constant. At 24 hours, there was a significant difference in the passage time for intestinal contents between the high lipid diet (Diet 3) and the cellulose/high lipid diet (Diet 4); however, the high variation in data makes a determination at 24 hours very difficult.

The fish in salt water that were fed the high lipid diet (Diet 3) did not show movement of ingesta from the stomach during the first six hours after feeding. This finding agrees with that for the fish in fresh water. At 24 hours, the amount of the cellulose/high lipid diet (Diet 4) left in the stomach was almost 50% higher than that of the lipid alone. In Figure 5, there was again, a steep slope to the curve for the cellulose/lipid diet stomach content supporting the findings in the fresh water facility and Experiment 1 that the cellulose/lipid diet evacuated from the stomach more rapidly in the first 12 hours after feeding than did the other experimental diets. This indicates that the cellulose had accelerated the passage time of digesta. In contrast, Fange and Grove (1979) stated that additions of indigestible materials decreases the gastric evacuation rate. The cellulose diets in both Experiments 1 and 2 had a faster evacuation rate until 12 hours after which the remaining stomach contents took a long time to evacuate. The remaining content may have been mainly cellulose which was indigestible and therefore not moving out the stomach quickly. Analysis of the stomach contents for cellulose would be required to determine if this is the case.

In fresh water, fish that were fed the cellulose/high lipid diet (Diet 4) had less water in their stomach contents at 1 hour, the water level increasing steadily, until at 18 hours, the percentage of water in the stomach contents of fish that have eaten Diet 4 was higher than Diets 1 or 3 as seen in Figure 7.

In the salt water, stomach contents had an increasing level of water until approximately 12 hours after which the amount of water levelled off. This may have resulted from the fish continuing to drink during the hours after the feeding. In fresh water the percent of water of the stomach content increased slightly, which could have been a result of the water ingested while feeding or water coming out of the tissues into the stomach. There was no steady increase in water in the stomach contents as was seen in the stomach contents of fish in salt water.

The stomach contents of fish reared in fresh water having eaten the high lipid diet (Diet 3) had a low percentage of water when compared to the stomach contents of fish fed the other experimental diets. In salt water, the stomach contents of fish fed Diet 3 had a lower percentage of moisture for the first 12 hours but then increased rapidly in water content after 12 hours when over 50% of the stomach contents have passed through into the intestine.

The effect of moisture on the stomach contents has not been well documented. Its effect on the rate of passage could alter the rate of feeding and absorption of nutrients, and therefore should be further investigated.

4.0 CONCLUSIONS

In Experiment 1 the fish fed the cellulose diet had poor feed conversion compared with fish fed the other diets. This result would be anticipated since the concentration of available nutrients was reduced by the cellulose in the diet. The fish ate more of the diet due to the decreased energy supply in the diet. In Experiment 2, there was a shorter period of experimentation with conflicting results between the fresh water and salt water sites. In fresh water, the fish fed the high lipid diet had a better feed conversion than did the fish fed the basal diet. In salt water, fish fed the basal diet had a better feed conversion than did the fish fed the high lipid diet. A longer study in which growth, and feed:gain ratios were obtained, could determine if the decrease in protein levels, with an addition of cellulose, impairs growth if the energy level of the diet is maintained through high lipid levels.

Diet 3, Experiment 1, the diet containing an addition of a water soluble fibre (pectin) did not show any significant difference in evacuation times; however, when the graphs of the stomach contents are compared (Figure 1) the pectin diet took longer to evacuate to 50% of the initial fill than did the cellulose diet (Diet 4), the high lipid diet (Diet 2) or the control diet (Diet 1). Pectin appeared to slow the gastric evacuation rate down; however, in Experiment 1, only wet weights were used, therefore the larger quantities within the stomachs could have been due to a large percentage of water. It was noted that the pectin diet resulted in poorer growth and feed ratio conversions. Fibres such as pectin have been found to increase the viscosity of digesta, thereby lowering the digestion or absorption of certain nutrients (Storebakken and Austreng, 1987). It would therefore result in decreased growth and feed conversion ratios.

In Experiment 2, the high lipid content diet was found to evacuate rapidly after the initial 6 hours. Lipids have been cited as slowing evacuation rates but the results of these two experiments disagreed with the literature findings.

The cellulose/ high lipid diet (Diet 4) evacuated rapidly for the first 12 hours after which the rate of evacuation declined. The remaining contents stayed in the stomach significantly longer than the other diets. Further analysis of the stomach contents at 12, 18 and 24 hours could have determined if there was a higher percentage of cellulose within the remaining contents. The cellulose portion of the diet may have remained longer within the stomach, resulting in a slower evacuation rate overall.

Cellulose has been found to impair protein utilization from the diet (Fange and Grove, 1979). However, with the addition of lipid, the energy required for metabolic maintenance may be adequate to sustain maximum growth if sufficient protein and essential amino acids are provided within the diet. The cellulose/high lipid diet, although having a high lipid content, had a poor feed conversion when compared to the other experimental diets, indicating that the cellulose may have impaired protein assimilation and therefore growth even when there was available energy in the form of lipid. The energy level of Diet 4, was maintained by a high level of lipid, but the fish ate more of this diet than the other diets when consumption and the quantities of stomach fill at 1 hour were compared.

There was a significant difference in the water content of the stomach contents of fish fed in fresh water versus fish fed in salt water. There was more water found in the stomach contents of fish reared in salt water. Fish drink water while in salt water which resulted in a significant difference in moisture levels in the ingesta in the stomach. The water content affects the fluidity of the stomach contents, contents evacuating faster when there is a higher water content of the ingesta. Also, the effect of a high water content on different feed ingredients could have affected the rate of passage through the gastrointestinal system, by affecting the fluidity of the stomach contents as demonstrated by the pectin diet in Experiment 1.

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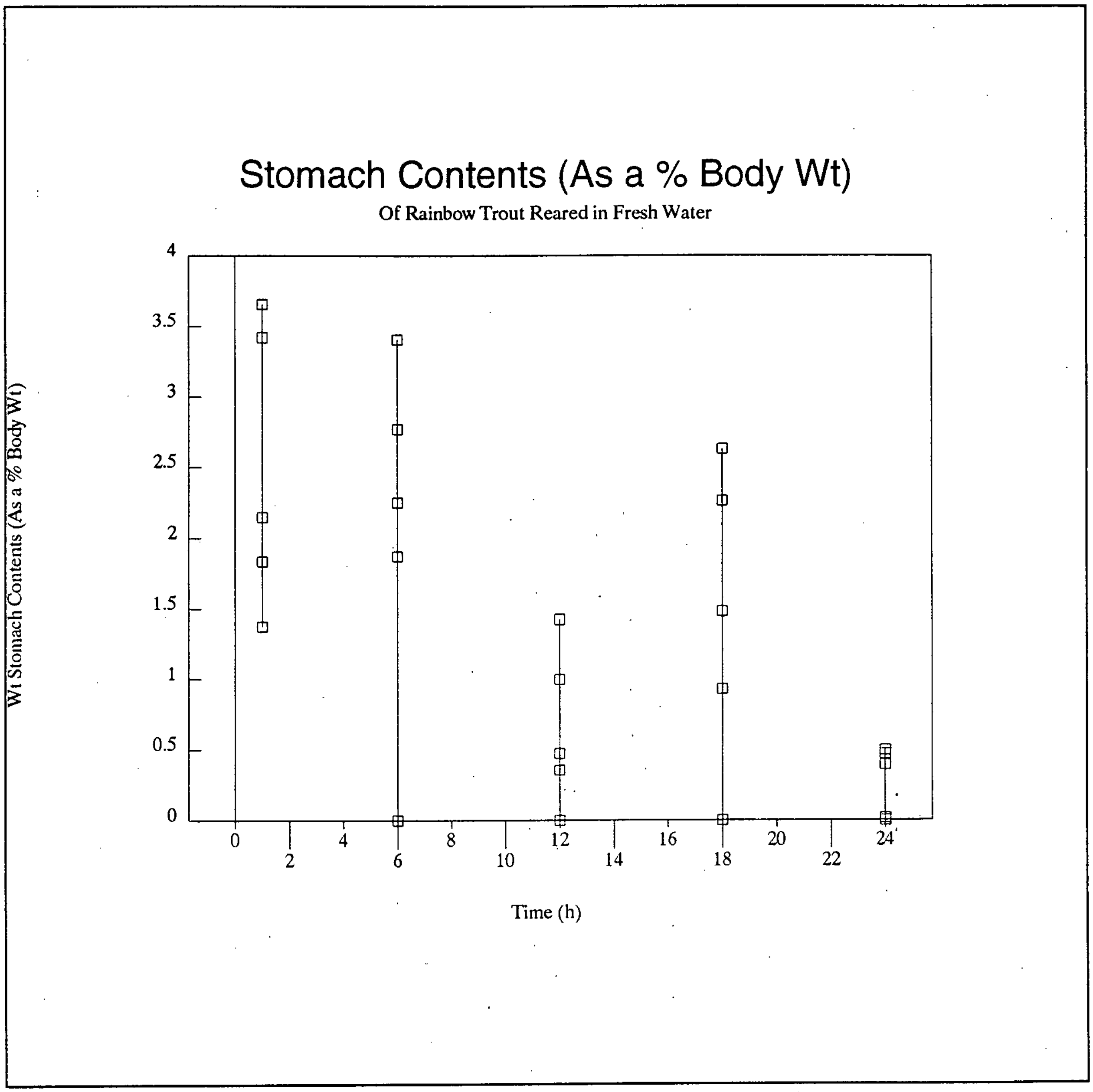
APPENDICES

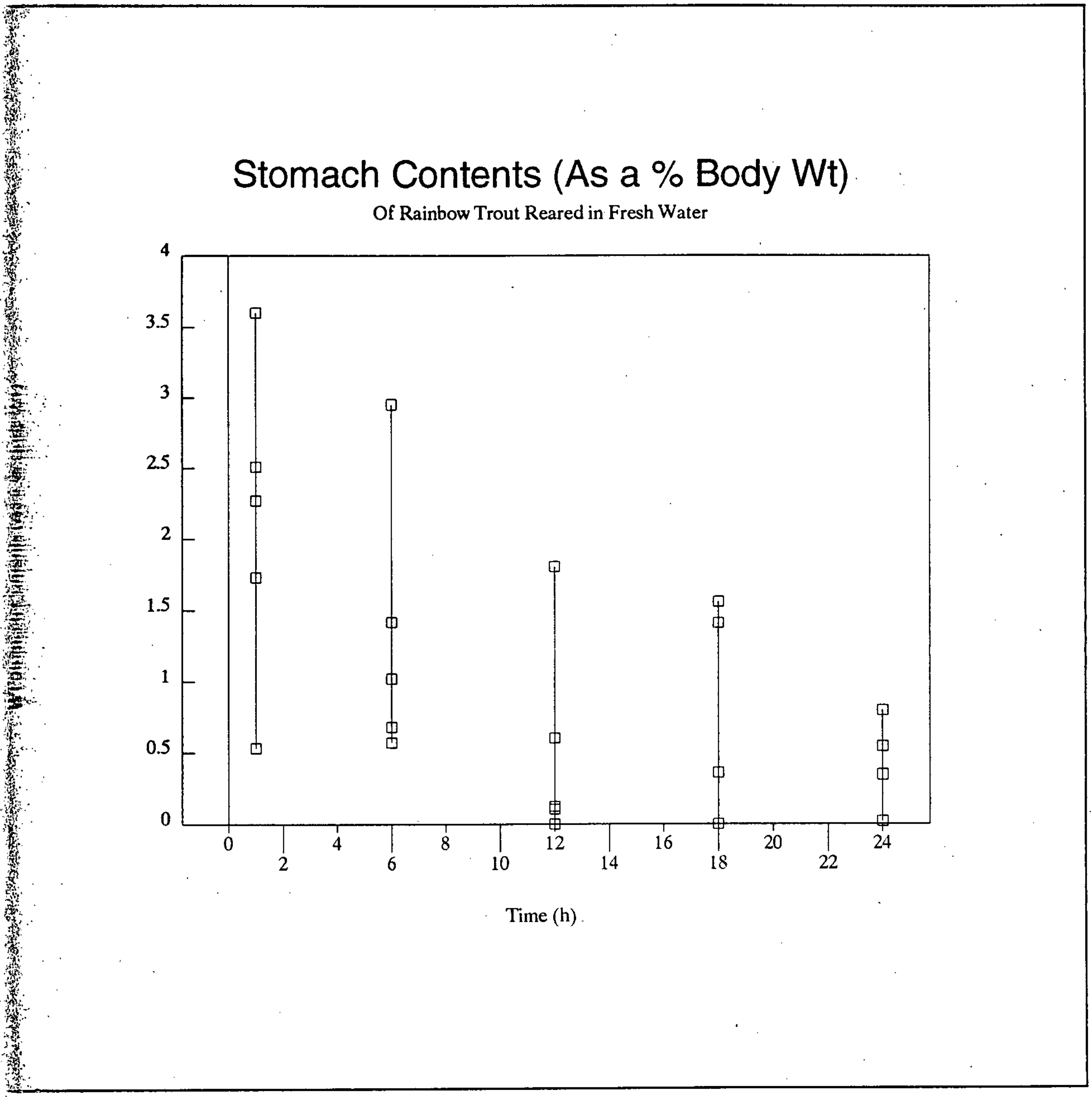
APPENDIX 1: Experiment 1: Stomach Contents Of Fish Reared in Fresh Water (Wet weight (g) as % Body Weight).

FIGURE 1A: Experiment 1: Stomach Contents Of Fish Reared on a Diet 1 in Fresh Water (Wet weight (g) as % Body Weight).



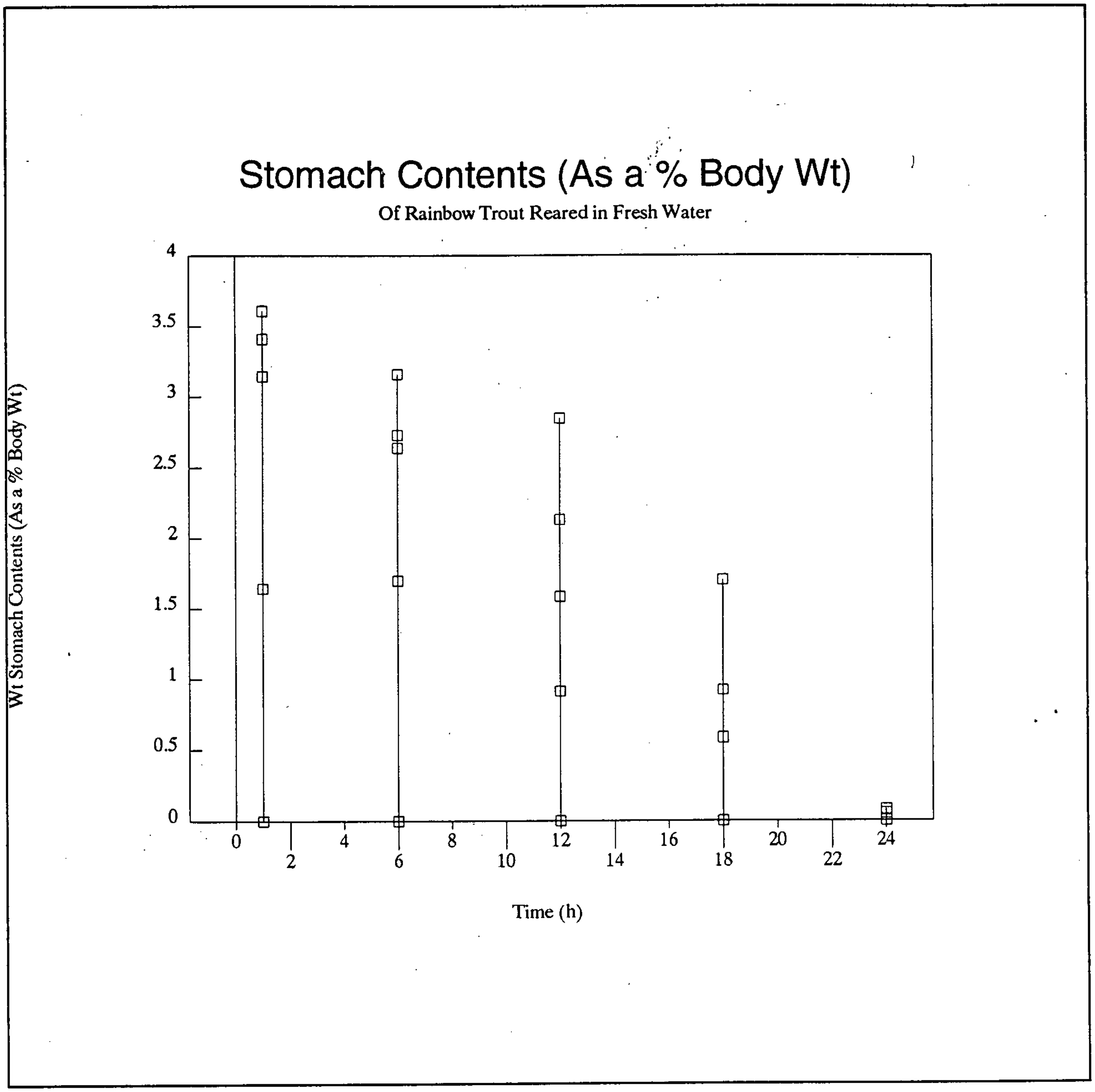
NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 1 = CONTROL DIET

FIGURE 2A: Experiment 1: Stomach Contents Of Fish Reared on Diet 2 in Fresh Water (Wet weight (g) as % Body Weight).



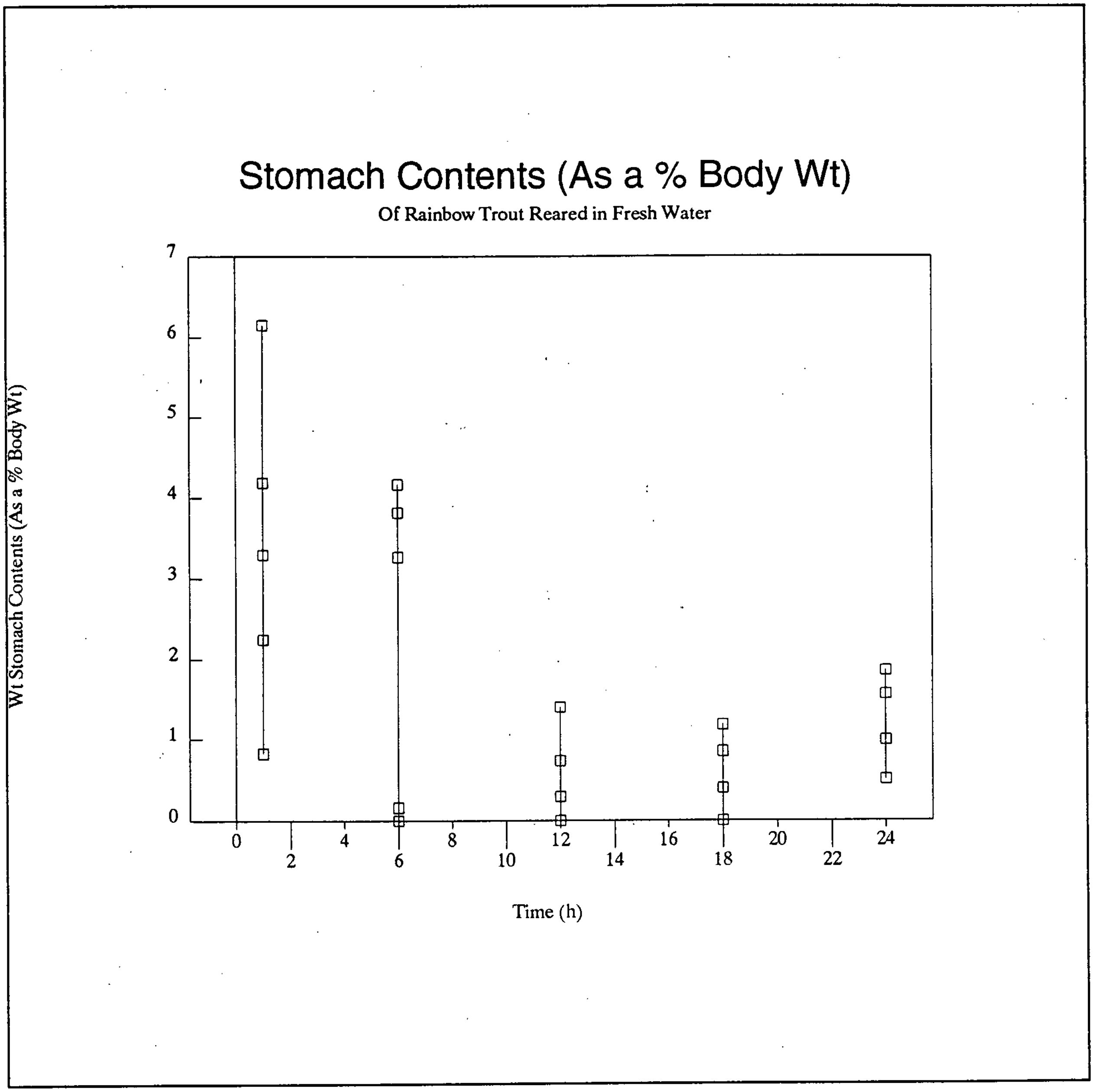
NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 2 = HIGH LIPID DIET

FIGURE 3A: Experiment 1: Stomach Contents Of Fish Reared on a Diet 3 in Fresh Water (Wet weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 3 =PECTIN DIET

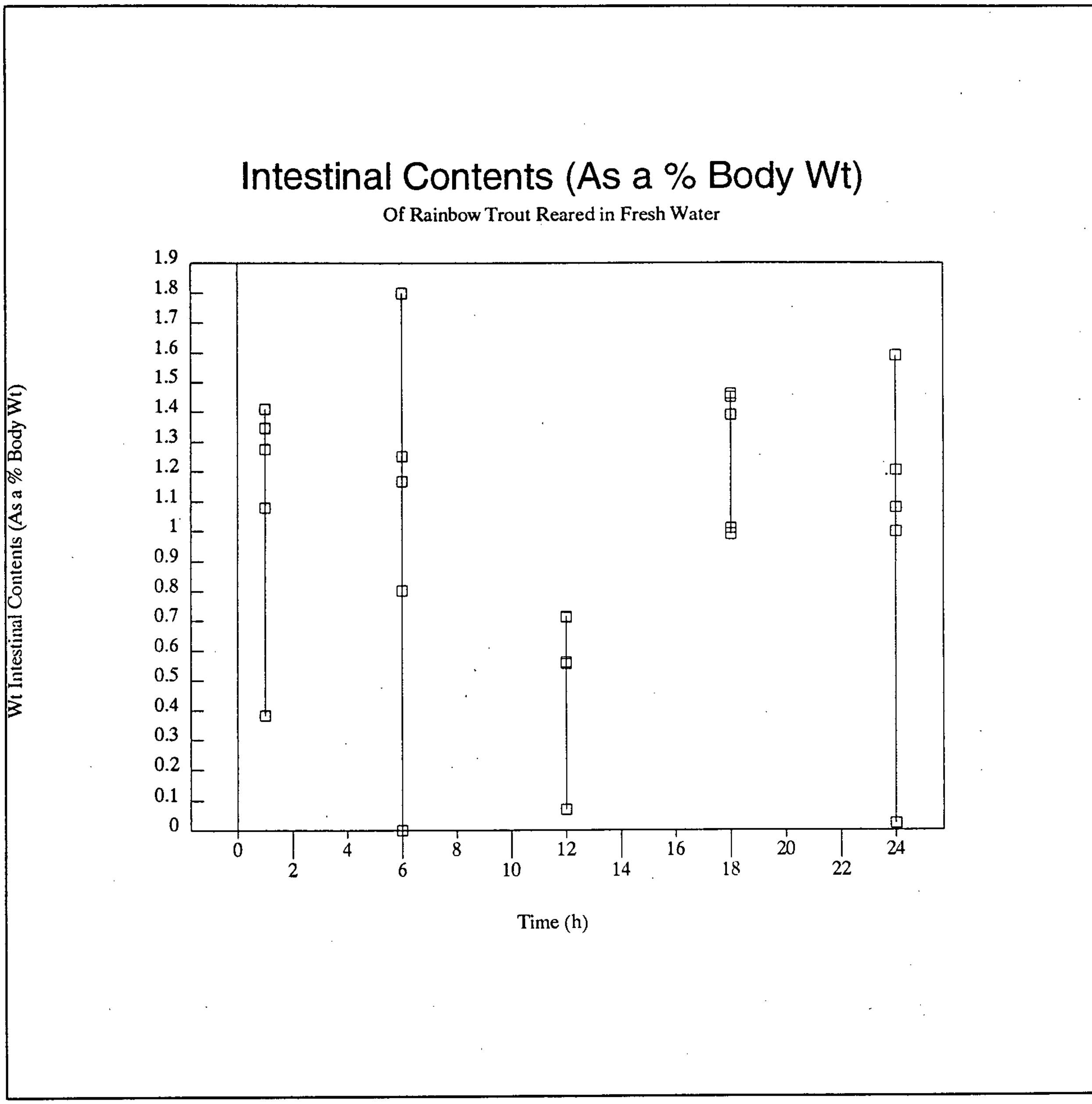
FIGURE 4A: Experiment 1: Stomach Contents Of Fish Reared on a Diet 4 in Fresh Water (Wet weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 4 = CELLULOSE DIET

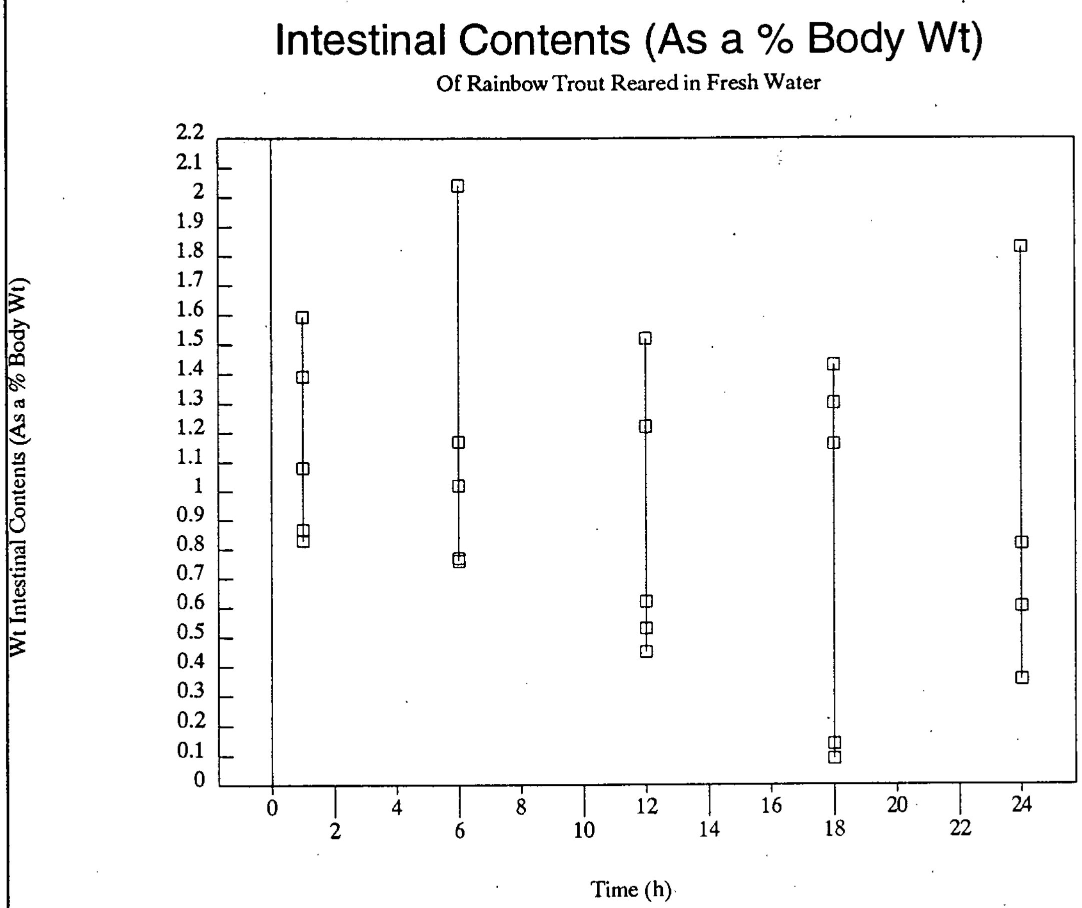
APPENDIX 2: Experiment 1: Intestinal Contents Of Fish Reared in Fresh Water (Wet weight of contents as a % Body Weight)

FIGURE 2A: Experiment 1: Intestinal Contents Of Fish Reared on a Diet 1 in Fresh Water (Wet weight (g) as % Body Weight).



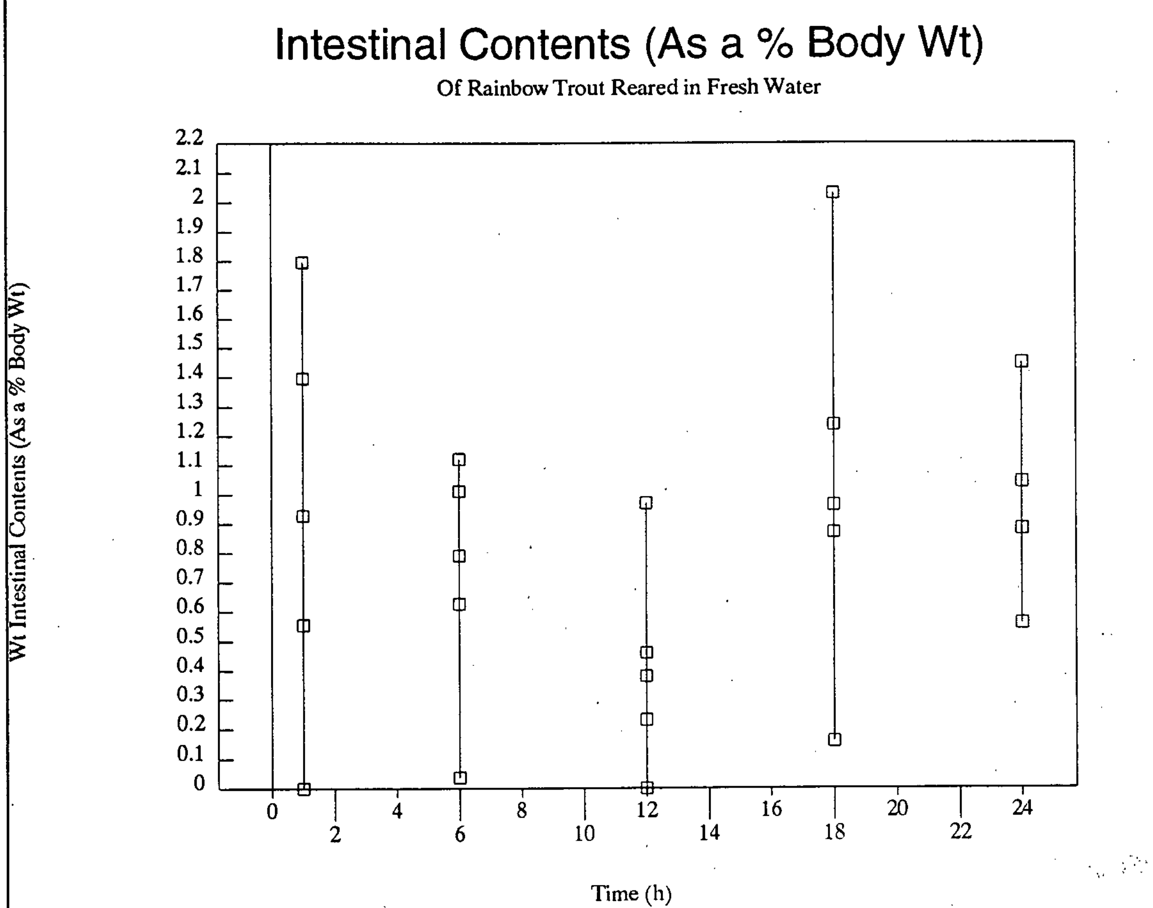
NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 1 = CONTROL DIET

FIGURE 2B: Experiment 1: Intestinal Contents Of Fish Reared on Diet 2 in Fresh Water (Wet weight (g) as % Body Weight).



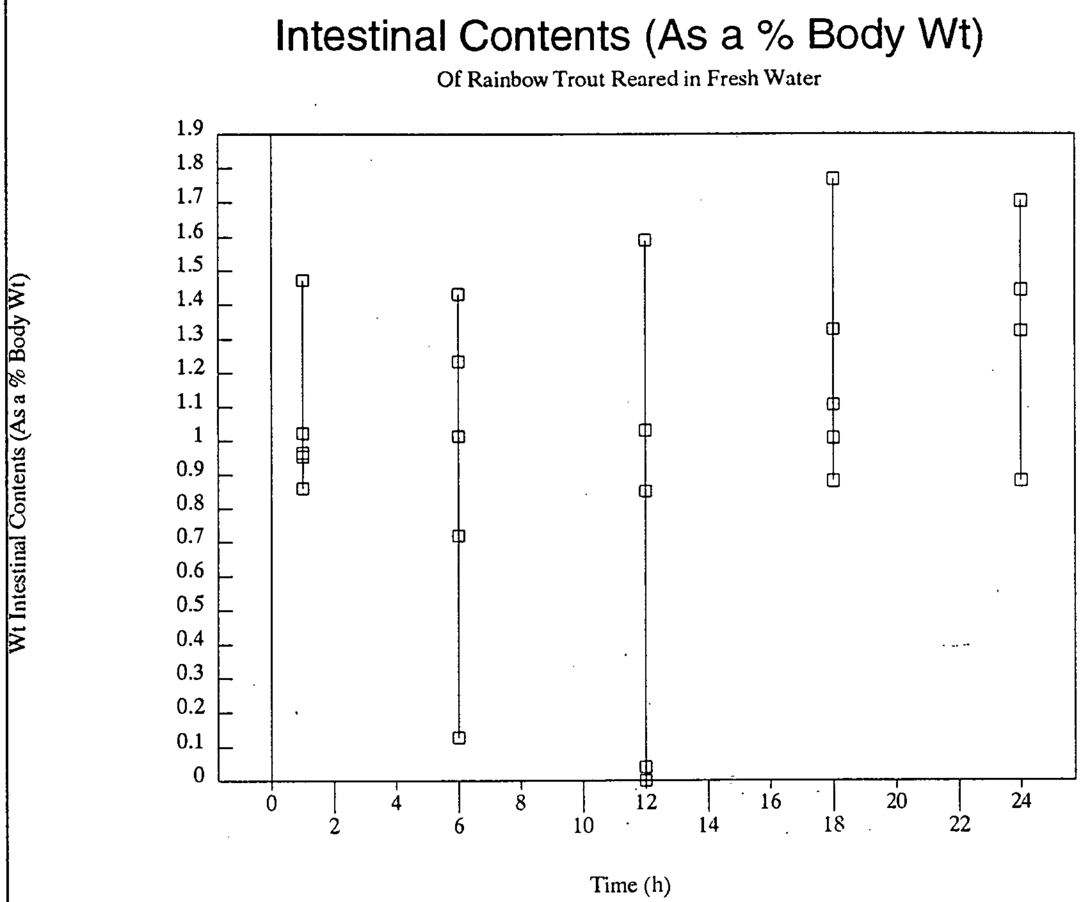
NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 2 = HIGH LIPID DIET

FIGURE 2C: Experiment 1: Intestinal Contents Of Fish Reared on Diet 3 in Fresh Water (Wet weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 3 = PECTIN DIET

FIGURE 2D: Experiment 1: Intestinal Contents Of Fish Reared on Diet 4 in Fresh Water (Wet weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 4 = CELLULOSE DIET

APPENDIX 3: Statistical Results Experiment 1 Fresh Water

ANOVA Results:

Stomach Contents

Time Period	Between Diets
1	P = 0.537
2	P = 0.210
3	P = 0.108
4	P = 0.168
5	P = 0.018

TUKEY HSD MULTIPLE COMPARISON FOR TIME PERIOD 5
Between Diets 1 and 4: P = 0.043
Between Diets 3 and 4: P = 0.029

Intestinal Contents

Time Period	Between Diets
1	P = 0.967
2	P = 0.231
3	P = 0.104
4	P = 0.547
5	P = 0.629

No significant difference between diets during any time period.

To test for Tank Effects and ANOVA was done. Results were P= 0.085.

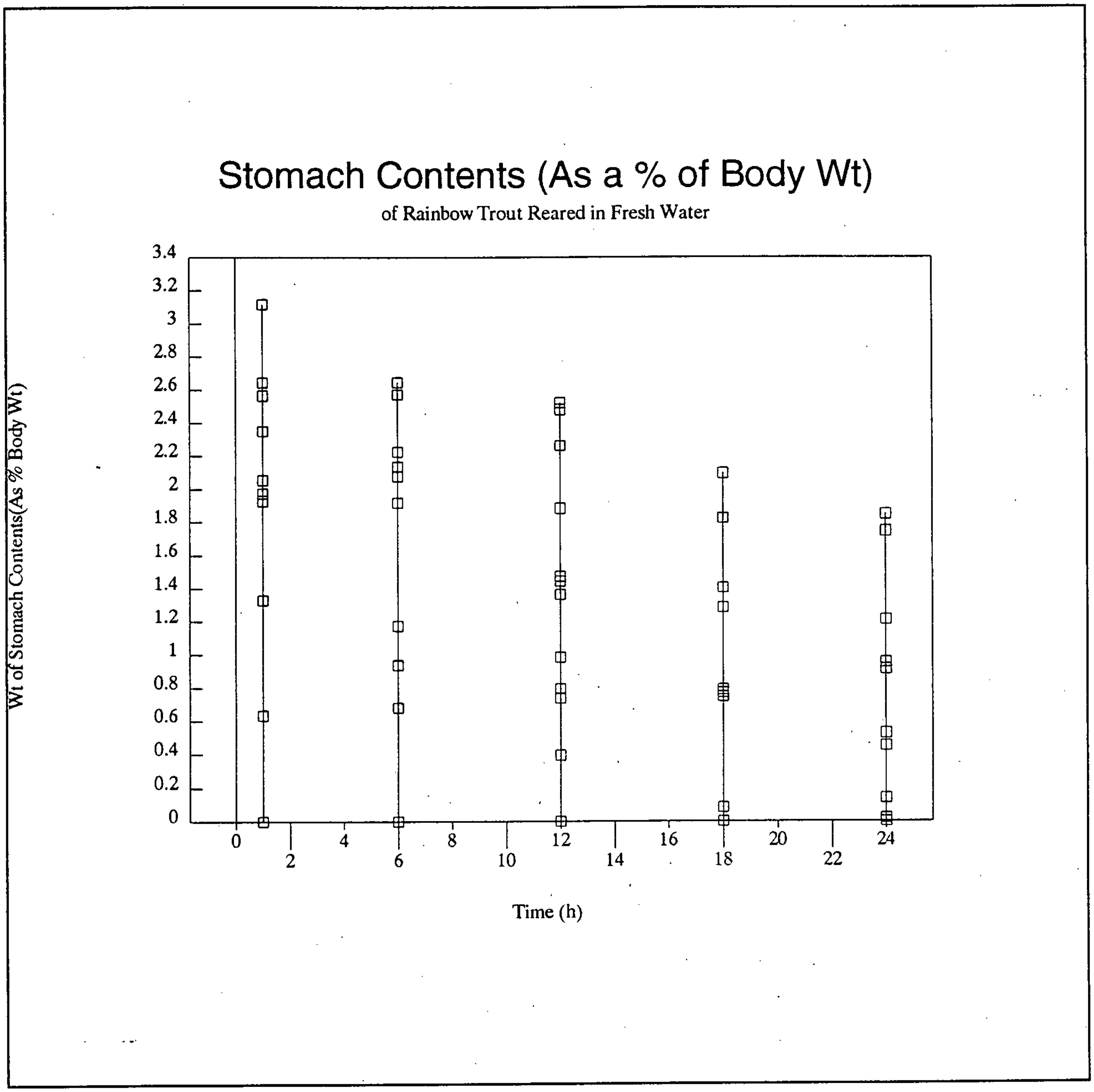
APPENDIX 4: EXPERIMENT 1, FRESH WATER, RAW DATA OF STOMACH AND INTESTINAL CONTENTS WET WEIGHTS

TIME	DIET 1	DIET 1	DIET 2	DIET 2	DIET 3	DIET 3	DIET 4	DIET 4
	%ST WET OVER BODY	%INT WET OVER BODY	%ST WET OVER BODY	%INT WET OVER BODY	%ST WET OVER BODY	%INT WET OVER BODY	%ST WET OVER BODY	%INT WET OVER BODY
1	3.42	1.28	0.53	0.83	0.00	0.00	6.15	0.86
1	3.66	0.38	2.51	0.87	1.64	0.55	3.29	0.96
1	1.84	1.41	1.73	1.08	3.41	1.80	4.19	0.95
1	1.37	1.08	2.27	1.39	3.14	1.40	2.25	1.02
1	2.15	1.35	3.60	1.59	3.61	0.93	0.83	1.47
MEAN	2.487	1.099	2.128	1.153	2.360	0.935	3.339	1.055
SD	0.896	0.375	1.003	0.297	1.367	0.628	1.795	0.215
6	0.00	0.00	1.42	0.76	2.64	0.79	3.27	1.01
6	2.25	1.25	0.57	0.77	1.70	0.63	3.82	0.72
6	3.40	1.80	0.68	1.02	0.00	0.04	4.16	1.23
6	1.87	0.80	2.95	2.04	3.15	1.12	0.00	0.13
6	2.76	1.17	1.02	1.17	2.73	1.01	0.16	1.43
MEAN	2.058	1.004	1.328	1.152	2.043	0.717	2.282	0.905
SD	1.150	0.595	0.864	0.470	1.126	0.381	1.820	0.455
12	0.00	0.07	0.00	1.22	0.00	0	1.39	0.85
12	0.48	0.71	0.60	0.45	2.13	0.38	0.74	1.03
12	1.42	0.56	0.12	0.62	0.91	0.97	0.00	0
12	0.36	0.71	0.11	0.53	1.58	0.23	0.00	0.04
12	0.99	0.56	1.80	1.52	2.84	0.46	0.29	1.59
MEAN	0.650	0.523	0.527	0.868	1.493	0.408	0.485	0.702
SD	0.501	0.237	0.671	0.424	0.980	0.322	0.529	0.608
18	0.93	1.45	0.36	1.16	0.00	2.03	1.17	1.10
18	2.26	1.46	1.41	1.43	1.70	1.24	0.85	1.77
18	0.00	1.39	0.00	0.09	0.00	0.16	0.85	1.33
18	1.48	1.01	1.56	1.30	0.92	0.87	0.40	0.88
18	2.62	0.99	0.00	0.14	0.58	0.96	0.00	1.01
MEAN	1.458	1.260	0.666	0.824	0.640	1.052	0.654	1.217
SD	0.939	0.214	0.683	0.585	0.636	0.605	0.409	0.312
24	0.39	1.21	0.54	0.82	0.00	1.45	0.50	1.44
24	0.00	0.02	0.80	0.35	0.08	0.88	1.56	0.88
24	0.47	1.00	0.02	0.60	0.00	0.56	1.86	1.70
24	0.02	1.08	0.34	1.83	0.05	1.04	0.98	1.32
24	0.49	1.59						
24								
MEAN	0.275	0.979	0.426	0.901	0.033	0.982	1.226	1.338
SD	0.220	0.520	0.284	0.561	0.034	0.319	0.522	0.297

NB: All zero values included for Mean and Standard Deviation (SD) of raw data. For tables of main body, determinations to include or exclude were made.

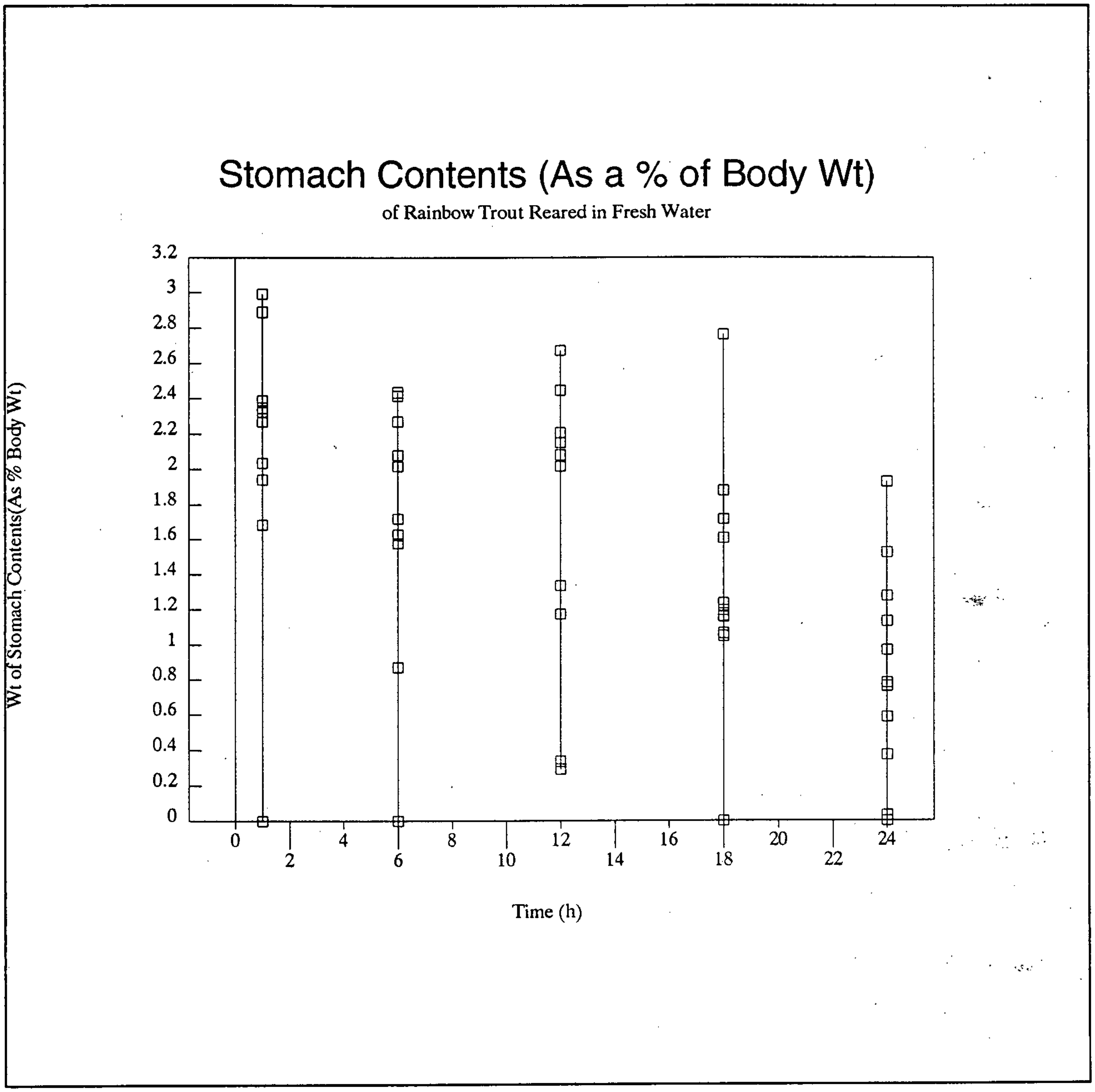
APPENDIX 5: Experiment 2: Stomach Contents Of Rainbow Trout Reared in Fresh Water

FIGURE 5A: Experiment 2: Stomach Contents Of Fish Reared on Diet 1 in Fresh Water (Dry weight (g) as % Body Weight).



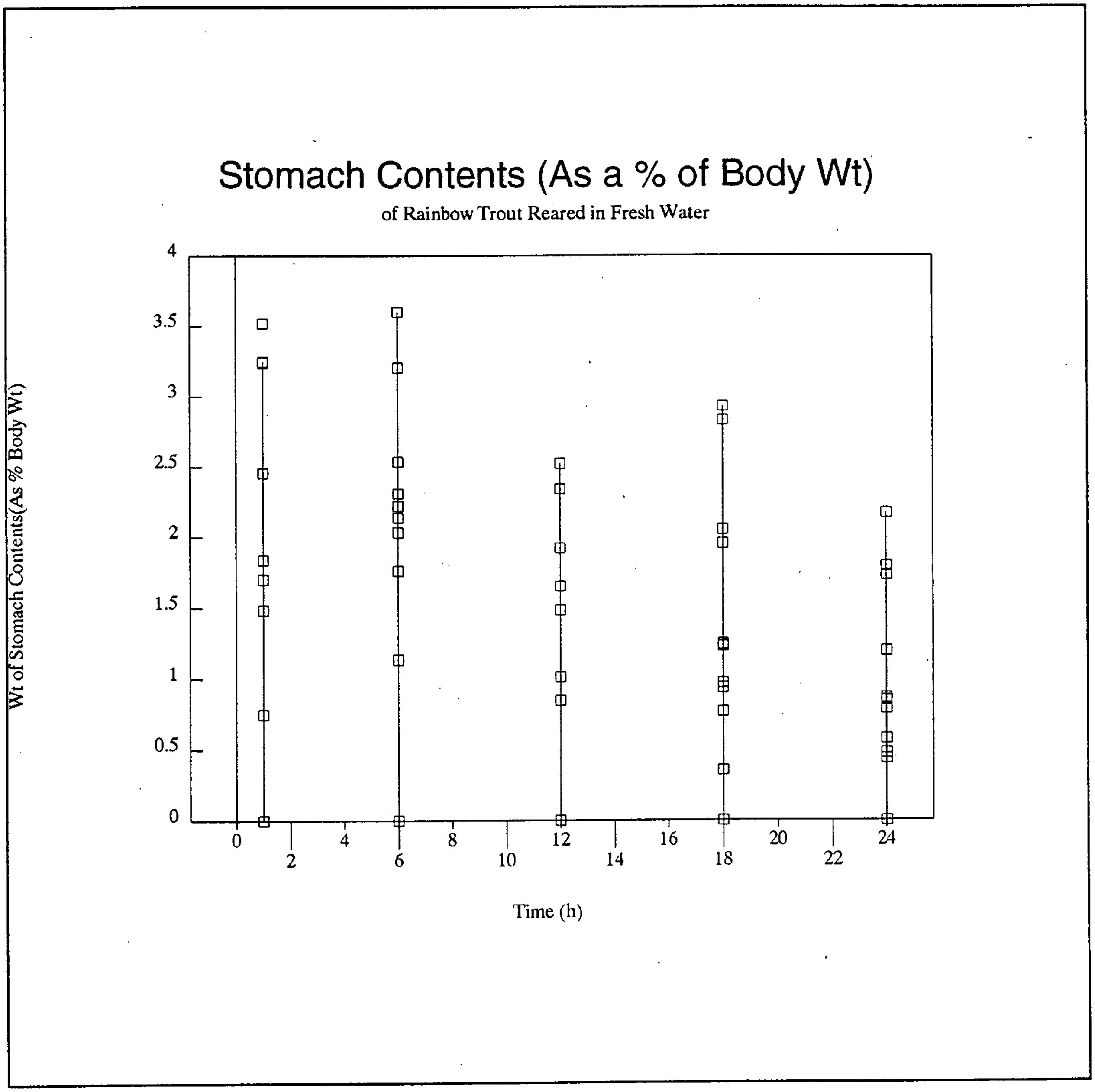
NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 1 = CONTROL DIET

FIGURE 5B: Experiment 2: Stomach Contents Of Fish Reared on Diet 2 in Fresh Water (Dry weight (g) as % Body Weight).



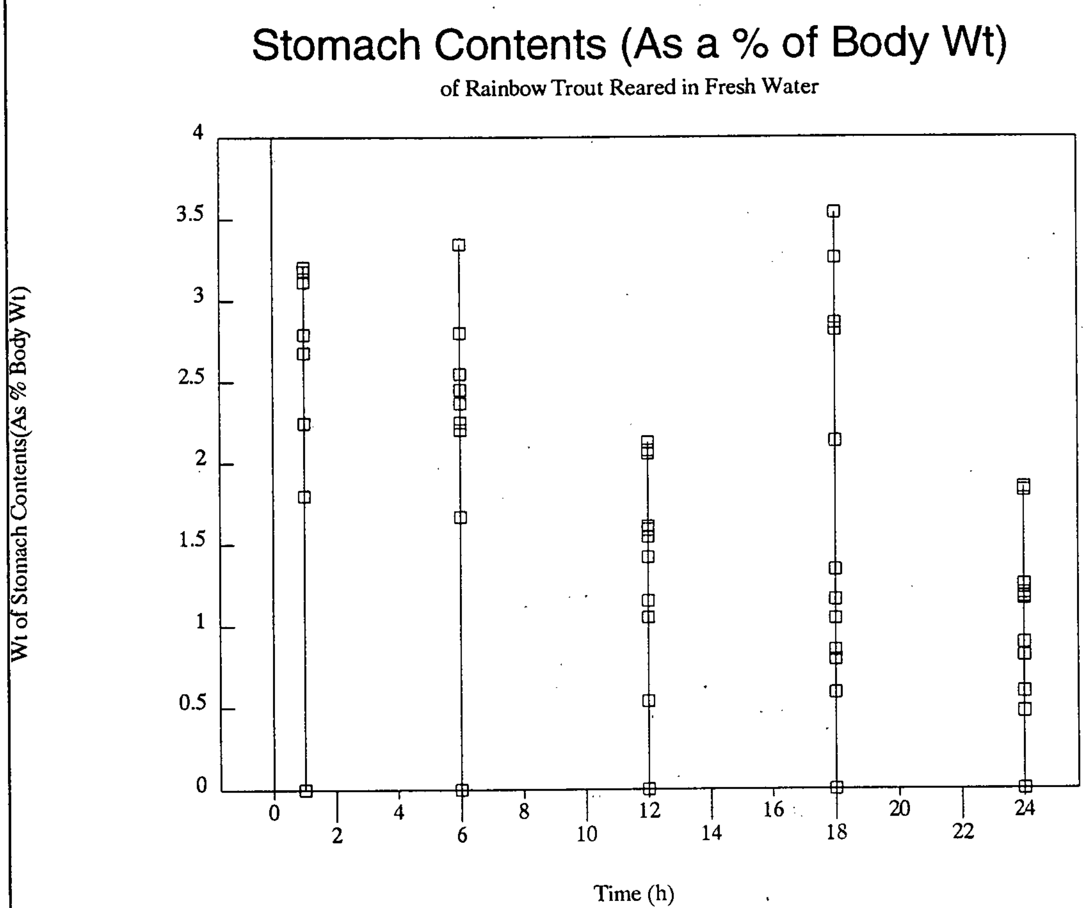
NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 2 = GELATIN DIET

FIGURE 5C: Experiment 2: Stomach Contents Of Fish Reared on Diet 3 in Fresh Water (Dry weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 3 = HIGH LIPID DIET

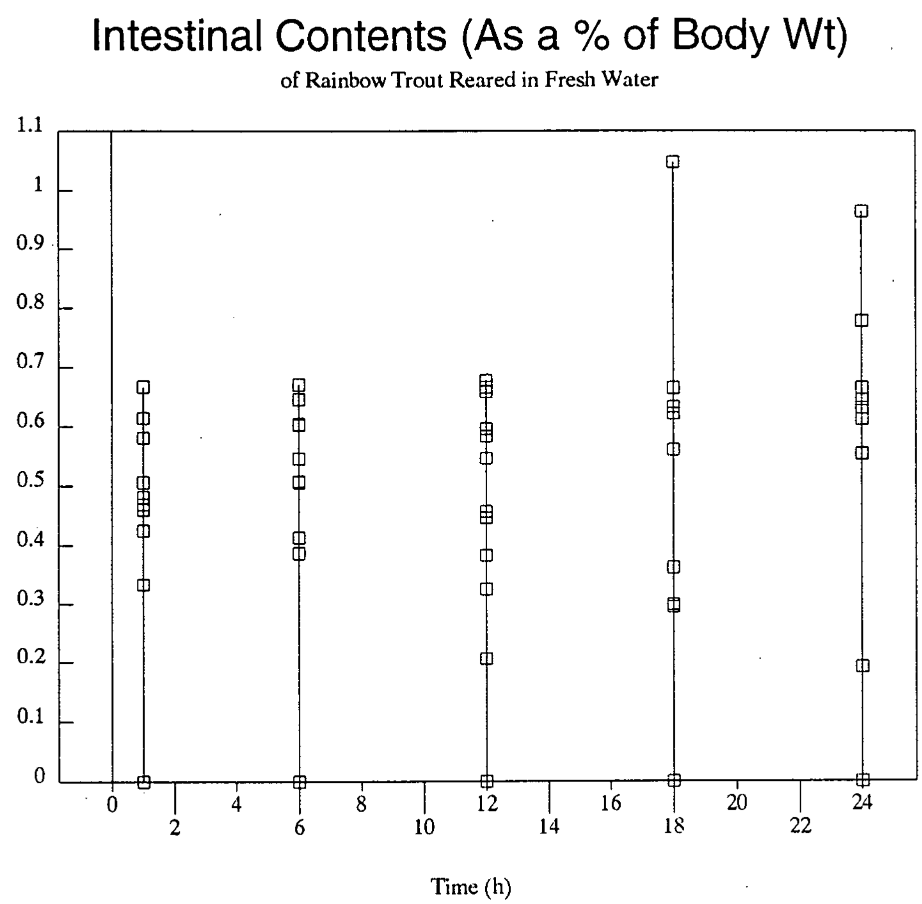
FIGURE 5D: Experiment 2: Stomach Contents Of Fish Reared on Diet 4 in Fresh Water (Dry weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 4 = CELLULOSE DIET

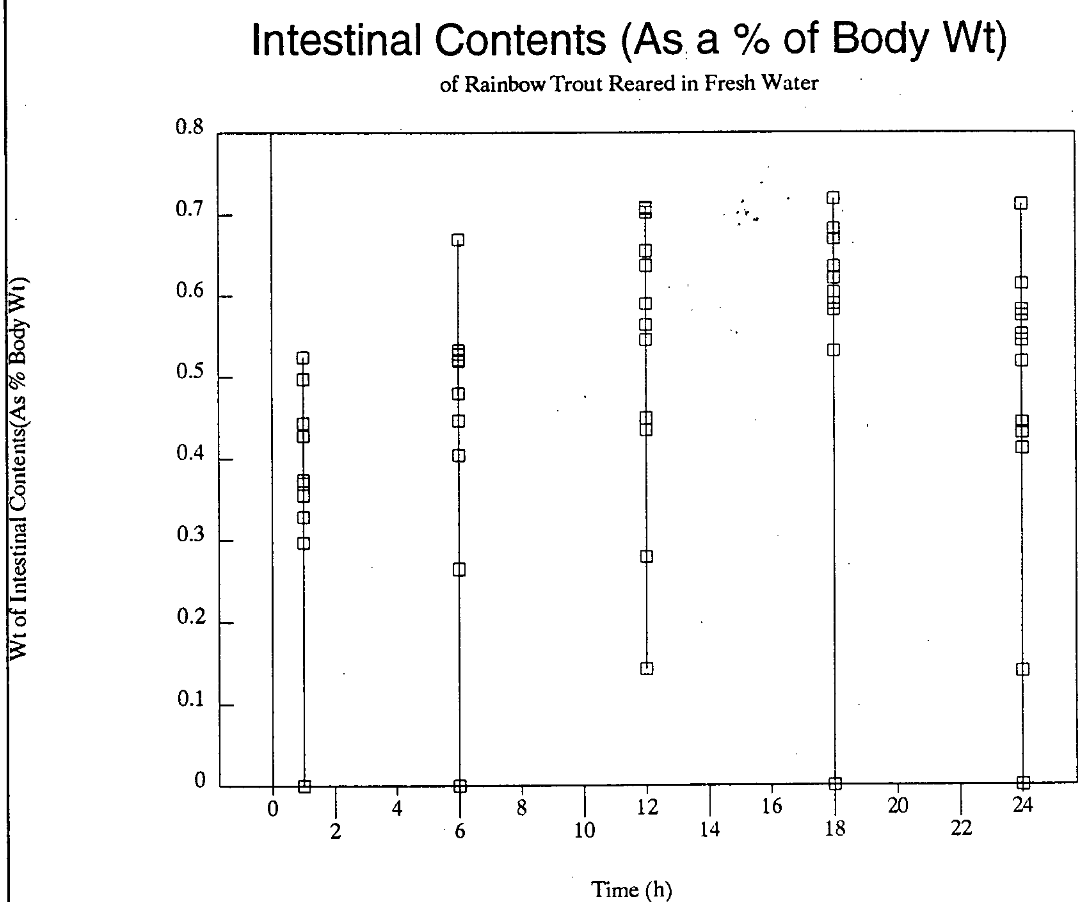
APPENDIX 6: Experiment 2: Intestinal Contents Of Rainbow Trout Reared in Fresh Water

FIGURE 6A: Experiment 2: Intestinal Contents Of Fish Reared on Diet 1 in Fresh Water (Dry weight (g) as % Body Weight).



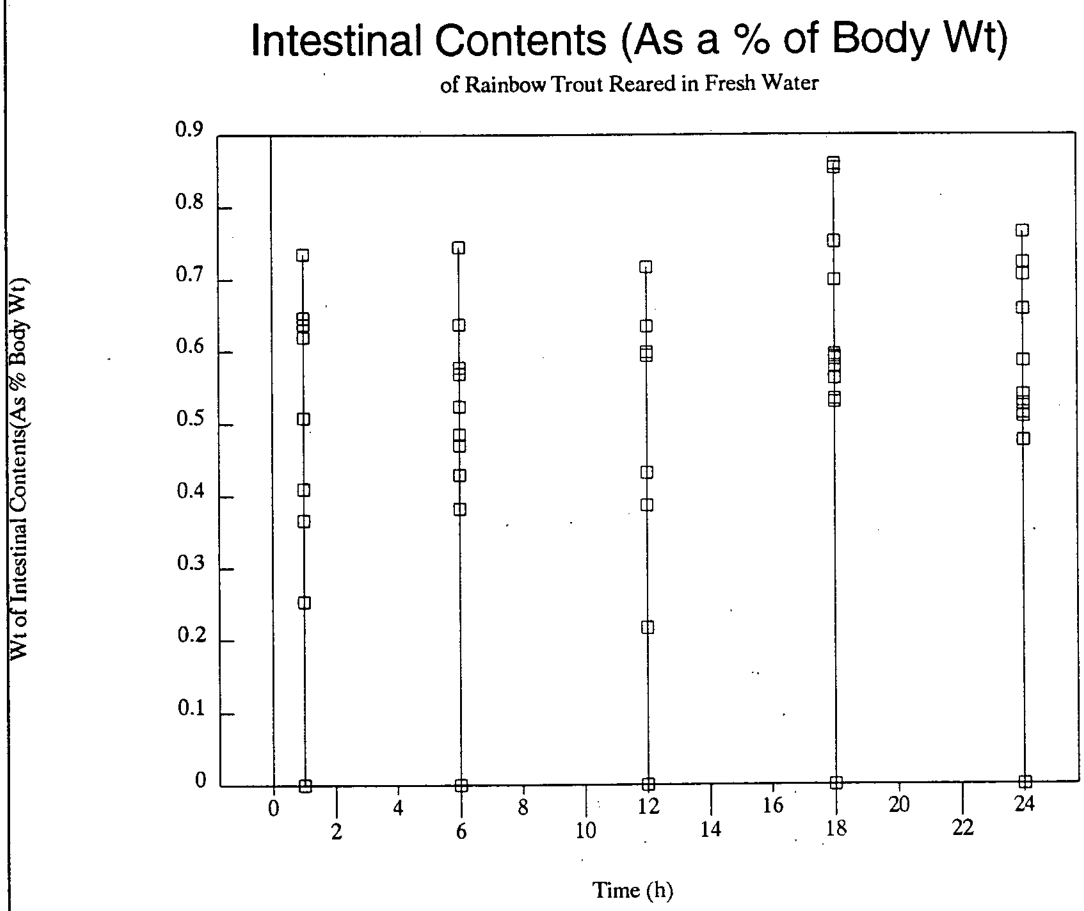
NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 1 = CONTROL DIET

FIGURE 6B: Experiment 2: Intestinal Contents Of Fish Reared on Diet 2 in Fresh Water (Dry weight (g) as % Body Weight).



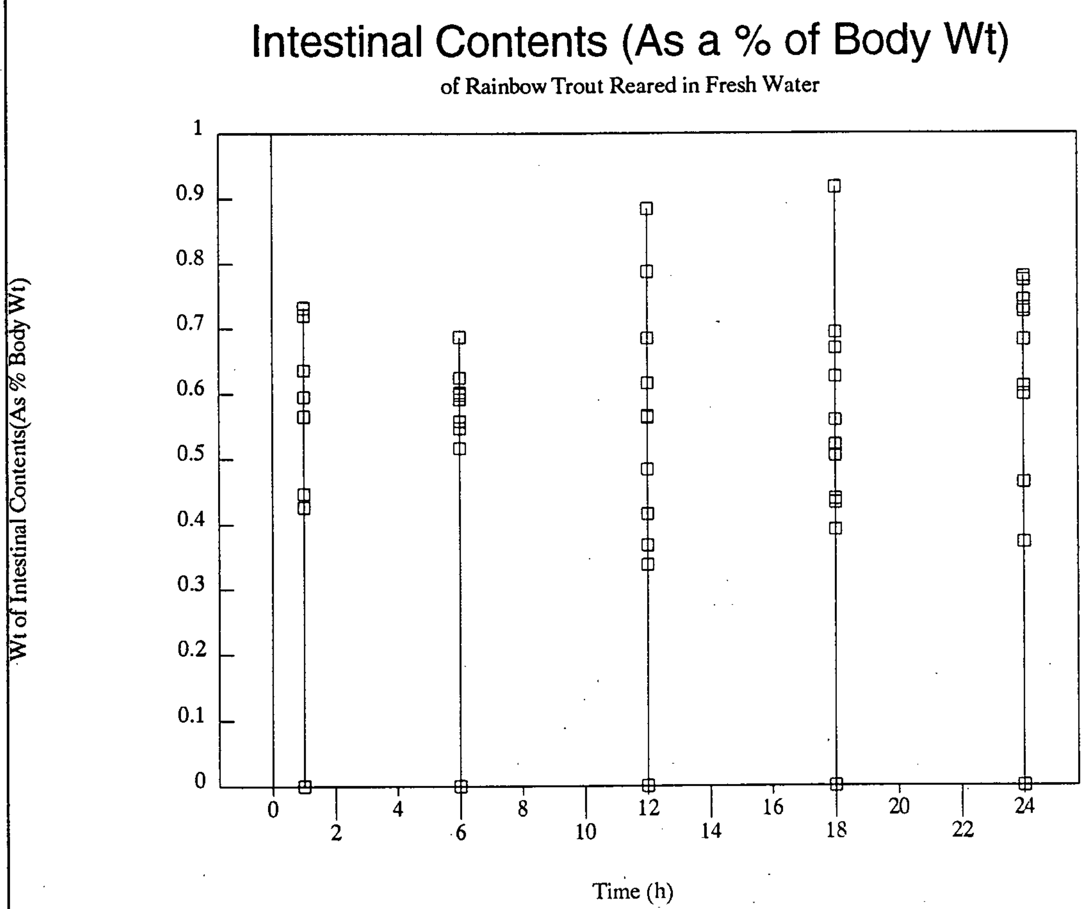
NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 2 = GELATIN DIET

FIGURE 6C: Experiment 2: Intestinal Contents Of Fish Reared on Diet 3 in Fresh Water (Dry weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 3 = HIGH LIPID

FIGURE 6D: Experiment 2: Intestinal Contents Of Fish Reared on Diet 4 in Fresh Water (Dry weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 4 = CELLULOSE/HIGH LIPID

APPENDIX 7: Statistical Results Experiment 2 Fresh Water

ANOVA Results:

Stomach Contents

Time Period	Between Diets
1	P = 0.354
2	P = 0.014*
3	P = 0.877
4	P = 0.318
5	P = 0.616

TUKEY HSD MULTIPLE COMPARISON
Between Diets 1 and 3: P = 0.043
Between Diets 1 and 4: P = 0.029

Intestinal Contents

Time Period	Between Diets
1	P = 0.030*
2	P = 0.441
3	P = 0.825
4	P = 0.505
5	P = 0.332

TUKEY HSD MULTIPLE COMPARISON
Between Diets 2 and 4: P = 0.020

To test for Tank Effects and ANOVA was done. Results were P= 0.233

APPENDIX 8: EXPERIMENT 2, STOMACH AND INTESTINAL CONTENTS OF RAINBOW TROUT REARED IN FRESH WATER

DIET	SAMPLING TIME (h)	TANK #	FISHWT (g)	STOMACH CONTENTS (g)	Stomach Contents (As a % of Body Wt)	Stomach (Wet Weight) (g)	Difference Stomach Weight Wet vs Dry (g)	Difference Wet vs Dry (As a % of Body Wt)	Intestinal Contents (g)	Intestinal Contents (As a % of Body Wt)	Intestinal Contents (Wet Weight) (g)	Difference Intestinal Contents Wet vs Dry (g)	Difference Wet vs Dry (As a % of Body Wt)
1	1	3	230	5.902	2.566	15.890	9.988	4.343	1.336	0.581	6.750	5.414	2.354
		3	303	9.445	3.117	22.081	12.636	4.170	1.007	0.332	5.188	4.181	1.380
		4	182	0.000	0.000	0.026	0.026	0.014	0.000	0.000	0.370	0.370	0.203
		4	216	5.714	2.645	16.190	10.476	4.850	1.326	0.614	6.622	5.296	2.452
		11	194	0.000	0.000	0.449	0.449	0.231	0.000	0.000	0.413	0.413	0.213
		11	201	3.967	1.974	10.478	6.511	3.239	1.017	0.506	5.425	4.408	2.193
		14	189	3.883	2.055	9.236	5.353	2.832	0.802	0.424	4.010	3.209	1.698
		14	268	3.560	1.328	8.011	4.451	1.661	1.256	0.469	6.081	4.825	1.800
		20	152	0.000	0.000	MT	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		20	284	6.680	2.352	18.566	11.886	4.185	1.366	0.481	7.441	6.075	2.139
		23	234	4.515	1.929	11.015	6.500	2.778	1.562	0.667	7.337	5.776	2.468
		23	246	1.561	0.635	3.693	2.132	0.867	1.133	0.460	5.826	4.693	1.908
		MEAN	225	3.769	1.550	9.636	5.867	2.431	0.900	0.378	4.622	3.722	1.567
		SD	43	2.845	1.080	7.229	4.427	1.736	0.553	0.234	2.676	2.126	0.881
2		1	257	5.833	2.270	17.866	12.033	4.682	1.278	0.497	6.418	5.141	2.000
		1	165	0.000	0.000	0.158	0.158	0.096	0.000	0.000	0.373	0.373	0.226
		2	207	4.859	2.347	15.401	10.542	5.093	0.772	0.373	4.167	3.395	1.640
		2	257	5.971	2.323	17.926	11.955	4.652	0.844	0.328	3.945	3.101	1.207
		8	215	6.429	2.990	17.600	11.171	5.196	1.127	0.524	6.171	5.044	2.346
		8	208	4.034	1.939	10.806	6.772	3.256	0.769	0.370	3.666	2.897	1.393
		10	230	5.492	2.388	17.240	11.748	5.108	0.683	0.297	3.643	2.960	1.287
		10	244	7.051	2.890	20.645	13.594	5.571	1.081	0.443	5.954	4.874	1.997
		13	172	3.500	2.035	11.593	8.093	4.705	0.735	0.427	3.679	2.945	1.712
		13	163	0.000	0.000	0.020	0.020	0.012	0.000	0.000	0.592	0.592	0.363
		16	142	0.000	0.000	0.149	0.149	0.105	0.000	0.000	0.769	0.769	0.542
		16	209	3.520	1.684	11.175	7.655	3.663	0.742	0.355	3.868	3.126	1.496
		MEAN	206	3.891	1.739	11.715	7.824	3.511	0.669	0.301	3.604	2.935	1.351
		SD	37	2.479	1.061	7.304	4.846	2.078	0.424	0.185	2.002	1.584	0.645
3		5	265	9.324	3.518	22.867	13.543	5.111	0.971	0.366	6.081	5.110	1.928
		5	261	8.455	3.239	21.371	12.916	4.949	1.664	0.637	9.022	7.358	2.819
		6	153	0.000	0.000	0.023	0.023	0.015	0.000	0.000	0.253	0.253	0.165
		6	321	7.892	2.458	18.465	10.573	3.294	2.075	0.647	10.220	8.145	2.537
		9	168	1.252	0.745	2.731	1.479	0.880	0.425	0.253	2.090	1.665	0.991
		9	283	4.202	1.485	9.724	5.523	1.951	1.161	0.410	6.773	5.612	1.983
		18	138	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.258	0.258	0.187
		18	236	7.660	3.246	18.174	10.514	4.455	1.199	0.508	5.858	4.659	1.974
		19	180	0.000	0.000	0.025	0.025	0.014	0.000	0.000	0.392	0.392	0.218
		19	170	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.294	0.294	0.173
		22	330	6.080	1.842	14.429	8.350	2.530	2.425	0.735	11.916	9.491	2.876
		22	234	3.980	1.701	9.545	5.565	2.378	1.449	0.619	7.160	5.712	2.441
		MEAN	228	4.070	1.520	9.780	5.709	2.131	0.947	0.348	5.026	4.079	1.524
		SD	63	3.566	1.316	8.682	5.122	1.902	0.826	0.277	4.060	3.240	1.057
4		0	187	5.226	2.794	11.351	6.125	3.276	1.057	0.565	4.608	3.551	1.899
		0	187	0.000	0.000	0.258	0.258	0.138	0.000	0.000	0.616	0.616	0.329
		7	155	0.000	0.000	0.006	0.006	0.004	0.000	0.000	0.219	0.219	0.141
		7	283	6.356	2.246	16.868	10.512	3.715	2.039	0.720	9.795	7.756	2.741
		12	210	0.000	0.000	0.299	0.299	0.142	0.000	0.000	2.101	2.101	1.000
		12	156	0.000	0.000	0.098	0.098	0.063	0.000	0.000	0.213	0.213	0.137
		15	266	8.517	3.202	19.665	11.148	4.191	1.134	0.426	5.789	4.655	1.750
		15	228	7.101	3.114	15.872	8.771	3.847	1.669	0.732	7.820	6.151	2.698
		17	156	0.000	0.000	0.068	0.068	0.044	0.000	0.000	0.362	0.362	0.232
		17	274	7.341	2.679	18.538	11.197	4.086	1.742	0.636	8.774	7.032	2.566
		21	272	4.884	1.796	12.141	7.257	2.668	1.618	0.595	7.553	5.936	2.182
		21	227	7.206	3.174	16.917	9.711	4.278	1.015	0.447	5.152	4.137	1.823
		MEAN	217	3.886	1.584	9.340	5.454	2.204	0.856	0.343	4.417	3.561	1.458
		SD	47	3.405	1.390	8.076	4.697	1.843	0.776	0.302	3.456	2.692	0.992

APPENDIX 8: EXPERIMENT 2 ,STOMACH AND INTESTINAL CONTENTS OF RAINBOW TROUT REARED IN FRESH WATER

DIET	SAMPLING TIME (h)	TANK #	FISHWT (g)	STOMACH CONTENTS (g)	Stomach Contents (As a % of Body Wt)	Stomach (Wet Weight) (g)	Difference Stomach Weight Wet vs Dry (g)	Difference Wet vs Dry (As a % of Body Wt)	Intestinal Contents (g)	Intestinal Contents (As a % of Body Wt)	Intestinal Contents (Wet Weight) (g)	Difference Intestinal Conts Wet vs Dry (g)	Difference Wet vs Dry (As a % of Body Wt)
1	6	3	226	2.650	1.172	7.810	5.160	2.283	1.365	0.604	6.505	5.140	2.275
		3	151	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.046	0.046	0.030
		4	145	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.111	0.111	0.077
		4	224	4.781	2.135	12.585	7.804	3.484	1.502	0.671	7.780	6.278	2.803
		11	292	6.065	2.077	17.611	11.546	3.954	1.477	0.506	7.421	5.944	2.036
		11	154	0.000	0.000	2.158	2.158	1.401	0.000	0.000	0.370	0.370	0.240
		14	260	6.874	2.644	18.631	11.757	4.522	1.567	0.603	7.601	6.034	2.321
		14	216	5.553	2.571	13.380	7.827	3.624	1.395	0.646	6.690	5.295	2.452
		20	241	5.363	2.225	14.248	8.885	3.687	1.315	0.545	6.984	5.670	2.352
		20	297	5.699	1.919	16.463	10.764	3.624	1.507	0.508	7.449	5.942	2.001
		23	216	2.019	0.935	5.888	3.869	1.791	0.834	0.386	4.570	3.736	1.730
		23	231	1.574	0.682	5.904	4.330	1.874	0.954	0.413	5.009	4.055	1.755
		MEAN	221	3.381	1.363	9.557	6.175	2.520	0.993	0.407	5.045	4.052	1.673
		SD	48	2.505	0.980	6.506	4.041	1.465	0.611	0.248	2.964	2.356	0.943
2		1	282	6.402	2.270	19.447	13.045	4.626	1.887	0.669	9.928	8.042	2.852
		1	223	3.833	1.719	12.415	8.582	3.848	0.995	0.446	12.415	11.420	5.121
		2	143	0.000	0.000	MT	0.000	0.000	0.000	0.000	0.290	0.290	0.203
		2	303	7.313	2.414	23.960	16.647	5.494	1.600	0.528	8.191	6.591	2.175
		8	172	0.000	0.000	0.025	0.025	0.015	0.000	0.000	0.355	0.355	0.206
		8	225	3.550	1.578	10.947	7.397	3.288	1.169	0.520	5.638	4.469	1.986
		10	176	3.547	2.015	10.802	7.255	4.122	0.466	0.265	2.036	1.570	0.892
		10	260	6.331	2.435	19.185	12.854	4.944	1.247	0.480	6.101	4.854	1.867
		13	224	4.653	2.077	14.254	9.601	4.286	1.167	0.521	5.768	4.601	2.054
		13	173	0.000	0.000	MT	0.000	0.000	0.000	0.000	0.523	0.523	0.302
		16	194	1.688	0.870	4.861	3.173	1.636	1.033	0.533	4.720	3.687	1.900
		16	222	3.608	1.625	13.058	9.450	4.257	0.896	0.404	4.113	3.217	1.449
		MEAN	216	3.410	1.417	10.746	7.336	3.043	0.872	0.364	5.007	4.135	1.751
		SDS	46	2.456	0.914	7.760	5.317	1.972	0.603	0.228	3.709	3.227	1.312
3		5	299	6.389	2.137	15.691	9.302	3.111	1.906	0.637	9.638	7.732	2.586
		5	216	4.987	2.309	13.565	8.578	3.971	1.609	0.745	7.498	5.889	2.726
		6	246	8.857	3.600	22.290	13.433	5.461	1.398	0.568	7.048	5.650	2.297
		6	163	0.000	0.000	MT	0.000	0.000	0.000	0.000	0.309	0.309	0.190
		9	199	0.000	0.000	0.167	0.167	0.084	0.000	0.000	0.664	0.664	0.334
		9	204	2.314	1.134	5.920	3.607	1.768	0.958	0.469	4.504	3.546	1.738
		18	262	4.611	1.760	12.747	8.136	3.105	1.271	0.485	6.405	5.134	1.960
		18	234	7.495	3.203	18.599	11.104	4.745	1.352	0.578	7.359	6.008	2.567
		19	289	7.325	2.535	18.470	11.145	3.856	1.513	0.524	7.631	6.118	2.117
		19	303	6.724	2.219	16.404	9.681	3.195	1.159	0.382	16.404	15.245	5.031
		22	194	3.945	2.033	10.668	6.723	3.466	0.833	0.429	4.083	3.250	1.675
		22	211	0.000	0.000	0.076	0.076	0.036	0.000	0.000	0.419	0.419	0.199
		MEAN	235	4.387	1.744	11.216	6.829	2.733	1.000	0.401	5.997	4.997	1.952
		SDS	43	3.033	1.172	7.555	4.533	1.780	0.637	0.249	4.353	3.904	1.289
4		0	236	5.308	2.249	14.170	8.862	3.755	1.292	0.548	6.372	5.080	2.152
		0	255	6.239	2.447	16.326	10.087	3.956	1.526	0.598	7.395	5.869	2.302
		7	214	7.153	3.342	17.926	10.773	5.034	1.265	0.591	5.987	4.722	2.206
		7	142	0.000	0.000	0.120	0.120	0.085	0.000	0.000	0.424	0.424	0.299
		12	192	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.600	0.600	0.313
		12	243	5.356	2.204	13.712	8.356	3.439	1.669	0.687	8.253	6.584	2.709
		15	254	6.015	2.368	16.216	10.202	4.016	1.314	0.517	6.298	4.984	1.962
		15	233	5.934	2.547	14.371	8.437	3.621	1.454	0.624	7.369	5.915	2.538
		17	173	0.000	0.000	0.050	0.050	0.029	0.000	0.000	0.121	0.121	0.070
		17	235	6.581	2.801	18.805	12.224	5.202	1.311	0.558	6.653	5.342	2.273
		21	269	4.487	1.668	11.949	7.462	2.774	1.618	0.601	7.229	5.611	2.086
		21	170	0.000	0.000	0.031	0.031	0.018	0.000	0.000	0.494	0.494	0.291
		MEAN	218	3.923	1.635	10.306	6.384	2.661	0.954	0.394	4.766	3.812	1.600
		SDS	38	2.845	1.214	7.461	4.633	1.957	0.685	0.281	3.135	2.452	0.979

APPENDIX 8: EXPERIMENT 2 ,STOMACH AND INTESTINAL CONTENTS OF RAINBOW TROUT REARED IN FRESH WATER

DIET	SAMPLING TIME (h)	TANK #	FISHWT (g)	STOMACH CONTENTS (g)	Stomach Contents (As a % of Body Wt)	Stomach (Wet Weight) (g)	Difference Stomach Weight Wet vs Dry (g)	Difference Wet vs Dry (As a % of Body Wt)	Intestinal Contents (g)	Intestinal Contents (As a % of Body Wt)	Intestinal Contents (Wet Weight) (g)	Difference Intestinal Contents Wet vs Dry (g)	Difference Wet vs Dry (As a % of Body Wt)
1	12	3	251	3.419	1.362	11.491	8.072	3.216	1.672	0.666	8.907	7.235	2.883
		3	228	3.354	1.471	9.257	5.903	2.589	1.359	0.596	8.840	7.481	3.281
		4	269	6.082	2.261	19.561	13.479	5.011	1.823	0.678	10.549	8.726	3.244
		4	247	6.221	2.519	18.423	12.202	4.940	1.627	0.659	9.260	7.633	3.090
		11	227	5.626	2.478	15.990	10.364	4.566	1.037	0.457	6.477	5.440	2.396
		11	211	1.671	0.792	5.441	3.770	1.787	0.435	0.206	2.163	1.728	0.819
		14	243	3.506	1.443	11.569	8.063	3.318	1.328	0.547	8.114	6.786	2.793
		14	266	5.008	1.883	15.321	10.313	3.877	1.017	0.382	6.819	5.803	2.181
		20	166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.158	2.158	1.300
		20	226	1.661	0.735	6.109	4.448	1.968	0.734	0.325	5.025	4.290	1.898
		23	190	0.749	0.394	3.919	3.170	1.668	0.848	0.446	6.222	5.375	2.829
		23	265	2.602	0.982	9.228	6.626	2.500	1.545	0.583	9.304	7.760	2.928
		MEAN	232	3.325	1.360	10.526	7.201	2.953	1.119	0.462	6.986	5.868	2.470
		SDS	30	1.997	0.782	5.788	3.820	1.440	0.524	0.198	2.629	2.121	0.751
2		1	265	3.537	1.335	12.534	8.997	3.395	1.736	0.655	9.394	7.658	2.890
		1	190	4.190	2.205	14.786	10.596	5.577	1.343	0.707	7.687	6.344	3.339
		2	270	5.441	2.015	20.138	14.697	5.443	1.913	0.709	10.773	8.860	3.281
		2	231	2.704	1.171	10.309	7.605	3.292	1.303	0.564	8.345	7.042	3.049
		8	207	4.304	2.079	15.510	11.206	5.414	0.929	0.449	5.885	4.956	2.394
		8	260	6.947	2.672	19.588	12.642	4.862	1.825	0.702	8.737	6.912	2.658
		10	229	5.601	2.446	16.881	11.280	4.926	0.995	0.435	4.575	3.580	1.563
		10	213	4.697	2.205	16.438	11.741	5.512	1.162	0.545	5.274	4.112	1.931
		13	175	0.587	0.336	1.764	1.177	0.672	0.249	0.142	1.289	1.040	0.594
		13	279	6.001	2.151	21.596	15.595	5.590	1.645	0.590	9.025	7.380	2.645
		16	203	0.595	0.293	3.471	2.876	1.417	0.566	0.279	4.158	3.593	1.770
		16	196	2.296	1.171	8.820	6.525	3.329	1.249	0.637	7.191	5.943	3.032
		MEAN	227	3.908	1.673	13.486	9.578	4.119	1.243	0.534	6.861	5.618	2.429
		SDS	33	1.955	0.763	6.081	4.204	1.630	0.485	0.172	2.561	2.122	0.786
3		5	193	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		5	273	4.055	1.485	13.418	9.363	3.430	1.057	0.387	11.507	10.450	3.828
		6	330	8.324	2.522	22.914	14.591	4.421	1.959	0.594	8.448	6.489	1.966
		6	291	5.592	1.922	18.794	13.202	4.537	1.847	0.635	11.605	9.758	3.353
		9	159	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		9	198	2.003	1.011	7.387	5.385	2.719	0.429	0.216	2.060	1.632	0.824
		18	150	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.966	1.966	1.311
		18	176	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.692	1.692	0.961
		19	312	5.153	1.652	15.017	9.865	3.162	2.235	0.716	12.576	10.341	3.314
		19	299	6.991	2.338	20.360	13.369	4.471	1.292	0.432	9.202	7.911	2.646
		22	176	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		22	253	2.142	0.847	8.235	6.093	2.408	1.514	0.598	8.704	7.190	2.842
		MEAN	234	2.855	0.961	8.844	5.989	2.096	0.861	0.298	5.647	4.786	1.754
		SDS	63	2.933	0.941	8.574	5.676	1.879	0.847	0.280	4.877	4.106	1.361
4		0	246	3.794	1.542	12.255	8.461	3.440	1.934	0.786	11.136	9.202	3.740
		0	140	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		7	177	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.525	0.525	0.297
		7	258	3.664	1.420	9.569	5.905	2.289	1.249	0.484	5.852	4.603	1.784
		12	221	4.542	2.055	12.724	8.182	3.702	1.248	0.565	5.679	4.431	2.005
		12	261	5.411	2.073	15.525	10.114	3.875	0.882	0.338	4.803	3.921	1.502
		15	221	4.693	2.123	14.928	10.236	4.632	1.954	0.884	10.922	8.969	4.058
		15	256	4.063	1.587	12.361	8.298	3.241	1.753	0.685	9.798	8.046	3.143
		17	245	2.825	1.153	11.225	8.400	3.429	1.507	0.615	8.536	7.029	2.869
		17	328	3.448	1.051	12.136	8.687	2.649	1.848	0.563	10.279	8.431	2.570
		21	276	1.481	0.536	5.875	4.395	1.592	1.146	0.415	7.502	6.356	2.303
		21	212	3.412	1.609	11.123	7.711	3.637	0.781	0.368	5.759	4.978	2.348
		MEAN	237	3.111	1.263	9.810	6.699	2.707	1.192	0.475	6.733	5.541	2.218
		SDS	46	1.679	0.715	4.975	3.362	1.424	0.651	0.263	3.573	2.938	1.172

APPENDIX 8: EXPERIMENT 2, STOMACH AND INTESTINAL CONTENTS OF RAINBOW TROUT REARED IN FRESH WATER

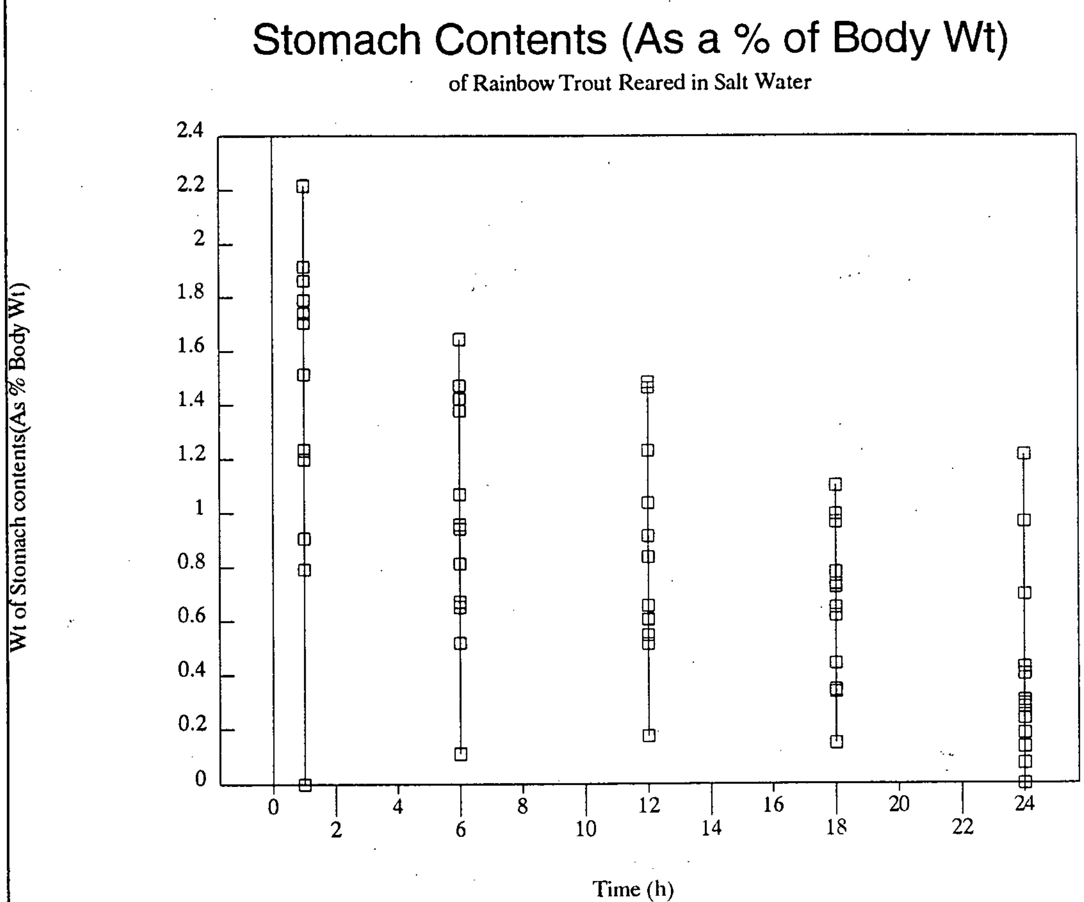
DIET	SAMPLING TIME (h)	TANK #	FISHWT (g)	STOMACH CONTENTS (g)	Stomach Contents (As a % of Body Wt)	Stomach (Wet Weight) (g)	Difference Stomach Weight Wet vs Dry (g)	Difference Wet vs Dry (As a % of Body Wt)	Intestinal Contents (g)	Intestinal Contents (As a % of Body Wt)	Intestinal Contents (Wet Weight) (g)	Difference Intestinal Conts Wet vs Dry (g)	Difference Wet vs Dry (As a % of Body Wt)
1	18	3	150	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.853	1.853	1.235
		3	260	4.737	1.822	17.787	13.050	5.019	1.644	0.632	9.869	8.225	3.164
		4	259	5.422	2.094	12.301	6.879	2.656	1.720	0.664	10.344	8.624	3.330
		4	218	3.056	1.402	8.103	5.047	2.315	2.282	1.047	8.567	6.285	2.883
		11	163	0.000	0.000	0.000	0.000	0.000		0.000	1.709	1.709	1.048
		11	152	0.000	0.000	0.000	0.000	0.000		0.000	1.740	1.740	1.145
		14	181	0.153	0.085	2.004	1.851	1.023	0.654	0.362	4.106	3.451	1.907
		14	228	1.705	0.748	6.804	5.099	2.237	1.416	0.621	8.374	6.958	3.052
		20	173	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000
		20	212	1.634	0.771	7.794	6.160	2.906	0.633	0.299	4.706	4.073	1.921
		23	203	1.599	0.788	6.086	4.487	2.210	1.137	0.560	6.988	5.851	2.882
		23	215	2.759	1.283	10.873	8.114	3.774	0.633	0.294	4.708	4.076	1.896
		MEAN	201	1.755	0.749	5.979	4.224	1.845	1.124	0.373	5.247	4.404	2.038
		SDS	36	1.825	0.728	5.557	3.898	1.591	0.668	0.325	3.378	2.676	1.001
2		1	237	4.061	1.714	15.194	11.133	4.697	1.586	0.669	8.988	7.402	3.123
		1	238	4.465	1.876	16.916	12.451	5.232	1.513	0.636	9.121	7.608	3.197
		2	242	2.807	1.160	11.154	8.348	3.449	1.739	0.719	10.969	9.230	3.814
		2	159	0.000	0.000	MT	0.000	0.000		0.000	MT	0.000	0.000
		8	188	3.020	1.606	12.355	9.335	4.965	1.094	0.582	6.714	5.620	2.990
		8	241	2.523	1.047	9.395	6.872	2.851	1.643	0.682	10.364	8.721	3.619
		10	236	2.818	1.194	12.064	9.246	3.918	1.500	0.636	8.973	7.473	3.166
		10	215	5.938	2.762	20.055	14.117	6.566	1.335	0.621	8.169	6.834	3.178
		13	187	0.000	0.000	MT	0.000	0.000		0.000	1.957	1.957	1.046
		13	280	2.977	1.063	12.649	9.672	3.454	1.690	0.604	10.241	8.551	3.054
		16	257	2.970	1.156	12.548	9.578	3.727	1.515	0.589	8.845	7.330	2.852
		16	187	2.304	1.232	11.449	9.145	4.890	0.994	0.531	6.916	5.923	3.167
		MEAN	222	2.823	1.234	11.148	8.325	3.646	1.461	0.522	7.605	6.387	2.767
		SDS	34	1.589	0.721	5.680	4.134	1.889	0.236	0.238	3.225	2.649	1.056
3		5	280	3.437	1.228	18.094	14.657	5.234	1.656	0.591	9.826	8.170	2.918
		5	281	2.152	0.766	9.922	7.770	2.765	1.486	0.529	11.615	10.129	3.605
		6	295	3.643	1.235	25.811	22.169	7.515	2.517	0.853	10.628	8.111	2.749
		6	305	8.917	2.924	12.674	3.757	1.232	1.815	0.595	13.909	12.094	3.965
		9	231	2.872	1.243	9.954	7.082	3.066	1.736	0.751	10.439	8.703	3.767
		9	229	0.812	0.355	5.026	4.214	1.840	1.347	0.588	8.981	7.634	3.333
		18	226	4.415	1.954	12.772	8.357	3.698	1.205	0.533	6.845	5.641	2.496
		18	318	3.082	0.969	11.034	7.952	2.501	1.840	0.578	11.284	9.445	2.970
		19	155	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		19	338	6.932	2.051	21.315	14.383	4.255	2.900	0.858	15.086	12.186	3.605
		22	266	2.491	0.937	8.663	6.172	2.320	1.494	0.562	9.899	8.405	3.160
		22	266	7.522	2.828	21.928	14.407	5.416	1.856	0.698	11.027	9.171	3.448
		MEAN	266	3.856	1.374	13.099	9.243	3.320	1.654	0.595	9.961	8.307	3.001
		SDS	48	2.574	0.867	7.147	5.838	1.964	0.676	0.211	3.629	3.049	0.996
4		0	209	5.979	2.861	18.317	12.338	5.903	1.088	0.521	7.611	6.523	3.121
		0	226	3.027	1.339	12.328	9.301	4.116	1.413	0.625	8.876	7.463	3.302
		7	200	5.637	2.818	17.148	11.511	5.755	0.877	0.438	4.992	4.116	2.058
		7	240	2.500	1.042	8.939	6.439	2.683	1.038	0.433	6.279	5.241	2.184
		12	264	8.599	3.257	27.817	19.218	7.279	1.831	0.693	10.403	8.572	3.247
		12	210	1.235	0.588	6.472	5.237	2.494	1.926	0.917	10.567	8.641	4.115
		15	295	6.286	2.131	17.862	11.576	3.924	1.154	0.391	6.661	5.506	1.867
		15	206	7.276	3.532	21.543	14.267	6.926	1.379	0.669	8.309	6.930	3.364
		17	143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		17	270	2.130	0.789	7.712	5.582	2.067	1.508	0.558	8.109	6.601	2.445
		21	229	1.942	0.848	7.315	5.373	2.346	1.156	0.505	6.256	5.101	2.227
		21	273	3.164	1.159	10.969	7.805	2.859	1.423	0.521	8.569	7.146	2.617
		MEAN	230	3.981	1.697	13.035	9.054	3.863	1.233	0.523	7.219	5.987	2.546
		SDS	40	2.565	1.122	7.386	4.867	2.113	0.476	0.209	2.898	2.231	0.998

APPENDIX 8: EXPERIMENT 2 ,STOMACH AND INTESTINAL CONTENTS OF RAINBOW TROUT REARED IN FRESH WATER

DIET	SAMPLING TIME (h)	TANK #	FISHWT (g)	STOMACH CONTENTS (g)	Stomach Contents (As a % of Body Wt)	Stomach (Wet Weight) (g)	Difference Stomach Weight Wet vs Dry (g)	Difference Wet vs Dry (As a % of Body Wt)	Intestinal Contents (g)	Intestinal Contents (As a % of Body Wt)	Intestinal Contents (Wet Weight) (g)	Difference Intestinal Contents Wet vs Dry (g)	Difference Wet vs Dry (As a % of Body Wt)
1	24	3	266	1.200	0.451	5.799	4.599	1.729	1.626	0.611	10.251	8.624	3.242
		3	318	5.871	1.846	19.396	13.525	4.253	3.065	0.964	15.132	12.068	3.795
		4	272	1.429	0.525	6.788	5.359	1.970	1.504	0.553	9.452	7.949	2.922
		4	279	2.544	0.912	8.999	6.455	2.314	1.797	0.644	10.093	8.296	2.973
		11	171	0.034	0.020	1.630	1.596	0.933	0.329	0.192	3.104	2.775	1.623
		11	235	2.240	0.953	8.943	6.702	2.852	1.561	0.664	9.504	7.943	3.380
		14	150	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		14	202	2.445	1.210	9.553	7.108	3.519	1.570	0.777	9.430	7.860	3.891
		20	150	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.816	1.816	1.210
		20	222	3.672	1.744	12.045	8.173	3.681	1.399	0.630	8.467	7.068	3.184
		23	184	0.261	0.142	2.323	2.062	1.120	1.018	0.553	5.914	4.896	2.661
		23	166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		MEAN	218	1.656	0.650	6.290	4.632	1.864	1.156	0.466	6.930	5.774	2.407
		SDS	54	1.768	0.651	5.676	3.938	1.438	0.890	0.317	4.544	3.670	1.312
		1	154	0.000	0.000	MT	0.000	0.000	0.000	0.000	1.811	1.811	1.176
2		1	225	1.316	0.585	9.675	8.359	3.715	1.601	0.712	8.579	6.978	3.101
		2	169	1.911	1.131	7.590	5.679	3.360	0.931	0.551	6.548	5.617	3.324
		2	290	3.695	1.274	16.954	13.259	4.572	1.503	0.518	7.792	6.289	2.169
		8	164	0.000	0.000	MT	0.000	0.000	0.228	0.139	2.610	2.382	1.453
		8	221	2.140	0.968	9.626	7.486	3.387	1.202	0.544	8.050	6.848	3.099
		10	215	1.685	0.784	7.276	5.592	2.601	1.236	0.575	8.636	7.400	3.442
		10	278	5.361	1.928	19.409	14.048	5.053	1.231	0.443	8.491	7.260	2.611
		13	279	4.249	1.523	15.521	11.272	4.040	1.712	0.614	3.239	1.527	0.547
		13	279	2.128	0.763	10.537	8.409	3.014	1.623	0.582	3.155	1.532	0.549
		16	199	0.061	0.031	1.739	1.678	0.843	0.818	0.411	5.355	4.537	2.280
		16	181	0.672	0.371	4.327	3.655	2.020	0.780	0.431	5.446	4.666	2.578
		MEAN	221	1.935	0.780	8.554	6.620	2.717	1.072	0.460	5.809	4.737	2.194
		SDS	48	1.666	0.596	6.168	4.570	1.617	0.523	0.194	2.459	2.252	0.992
3		5	239	1.143	0.478	4.809	3.666	1.534	1.686	0.705	8.458	6.772	2.834
		5	268	1.546	0.577	5.675	4.129	1.541	1.569	0.586	9.145	7.575	2.827
		6	178	1.398	0.785	5.688	4.290	2.410	0.906	0.509	6.223	5.317	2.987
		6	218	3.907	1.792	12.588	8.681	3.982	1.174	0.538	7.476	6.303	2.891
		9	216	0.948	0.439	5.282	4.334	2.007	1.135	0.525	7.215	6.080	2.815
		18	247	2.949	1.194	10.498	7.548	3.056	1.784	0.722	10.385	8.600	3.482
		18	239	2.029	0.849	7.782	5.752	2.407	1.828	0.765	10.179	8.351	3.494
		19	158	0.000	0.000	17.254	17.254	10.920		0.000	9.683	9.683	6.128
		19	261	5.660	2.169 ?				1.241	0.476	1.731	0.490	0.188
		22	219	3.787	1.729	12.413	8.626	3.939	1.125	0.514	6.909	5.784	2.641
		22	246	2.130	0.866	6.998	4.868	1.979	1.617	0.657	8.900	7.282	2.960
		MEAN	226	2.318	0.989	8.090	6.915	3.377	1.406	0.545	7.846	6.567	3.022
		SDS	32	1.550	0.633	4.530	3.883	2.649	0.309	0.196	2.333	2.296	1.293
4		0	237	1.402	0.592	7.166	5.763	2.432	1.847	0.779	10.035	8.188	3.455
		0	213	2.549	1.196	5.731	3.183	1.494	1.453	0.682	9.497	8.044	3.777
		7	259	2.315	0.894	8.885	6.570	2.537	1.879	0.725	10.876	8.998	3.474
		7	248	2.014	0.812	7.091	5.077	2.047	1.482	0.598	8.414	6.932	2.795
		12	214	0.000	0.000	0.000	0.000	0.000		0.000	2.122	2.122	0.991
		12	173	3.191	1.845	10.419	7.228	4.178	0.802	0.463	6.116	5.315	3.072
		15	198	2.478	1.251	9.259	6.781	3.425	1.209	0.611	6.944	5.735	2.897
		15	225	4.103	1.823	13.327	9.225	4.100	1.643	0.730	9.989	8.346	3.709
		17	217	2.548	1.174	9.617	7.069	3.258	1.677	0.773	8.847	7.170	3.304
		17	216	1.021	0.472	5.241	4.221	1.954	0.802	0.371	5.798	4.996	2.313
		21	163	0.000	0.000	0.000	0.000	0.000		0.000	1.711	1.711	1.050
		21	244	2.831	1.160	9.603	6.772	2.776	1.814	0.743	9.660	7.846	3.216
		MEAN	217	2.038	0.935	7.195	5.157	2.350	1.461	0.540	7.501	6.283	2.838
		SDS	28	1.182	0.577	3.833	2.740	1.311	0.382	0.269	2.928	2.293	0.900

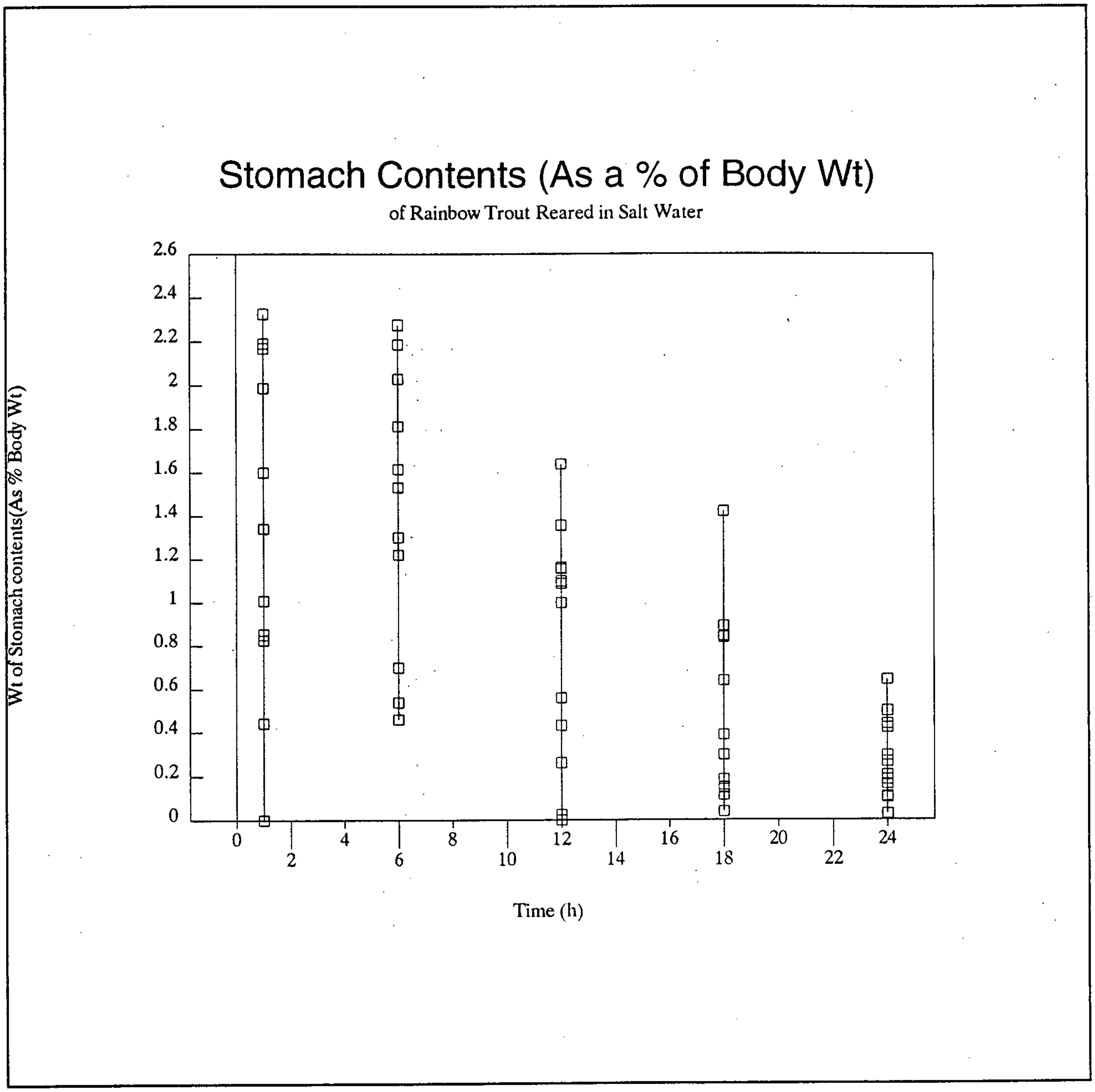
APPENDIX 9: Experiment 2: Stomach Contents Of Rainbow Trout Reared in Salt Water

FIGURE 9A: Experiment 2: Stomach Contents Of Fish Reared on Diet 1 in Salt Water (Dry weight (g) as % Body Weight).



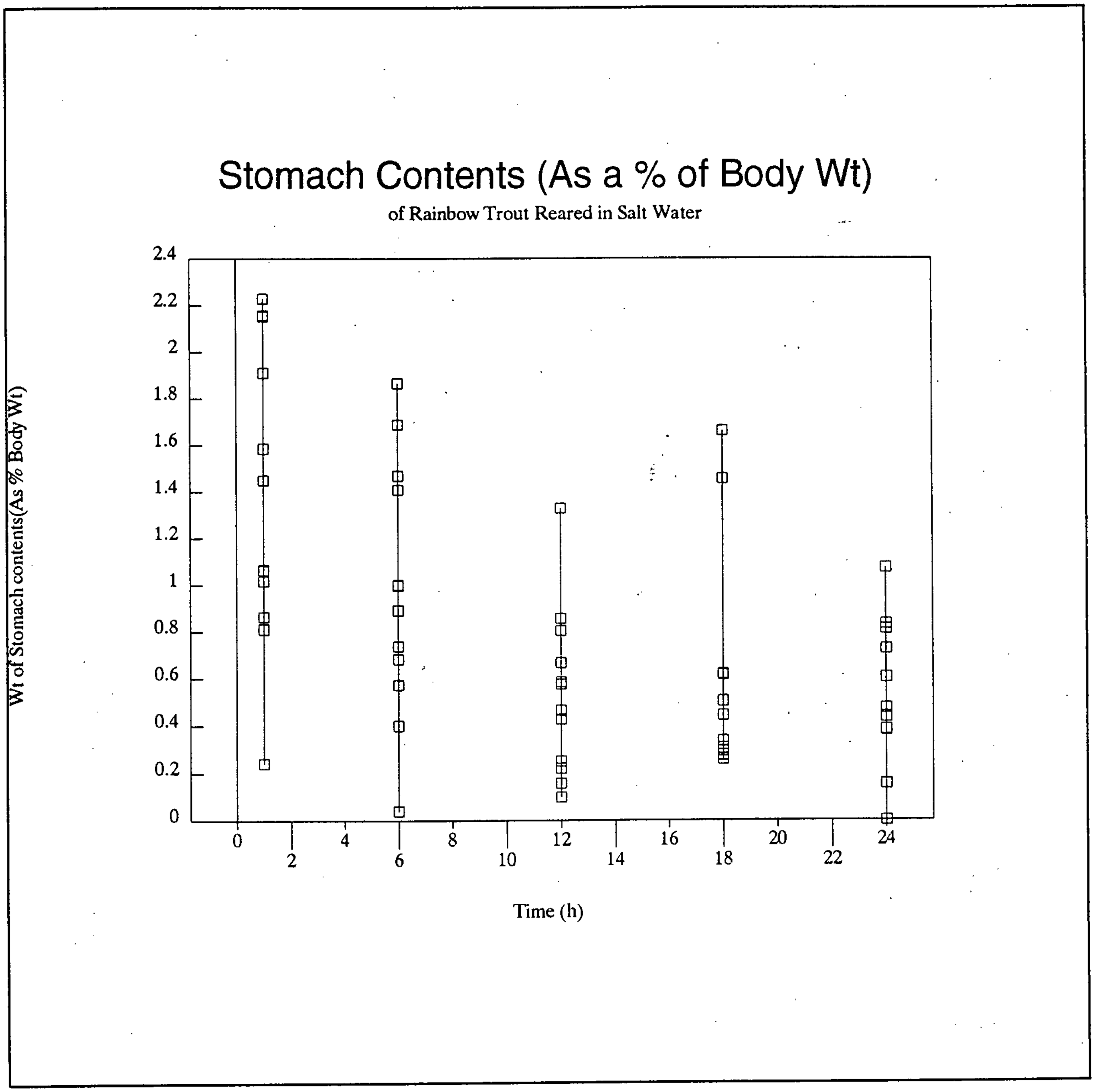
NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 1 = CONTROL

FIGURE 9B: Experiment 2: Stomach Contents Of Fish Reared on Diet 3 in Salt Water (Dry weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 3 = HIGH LIPID

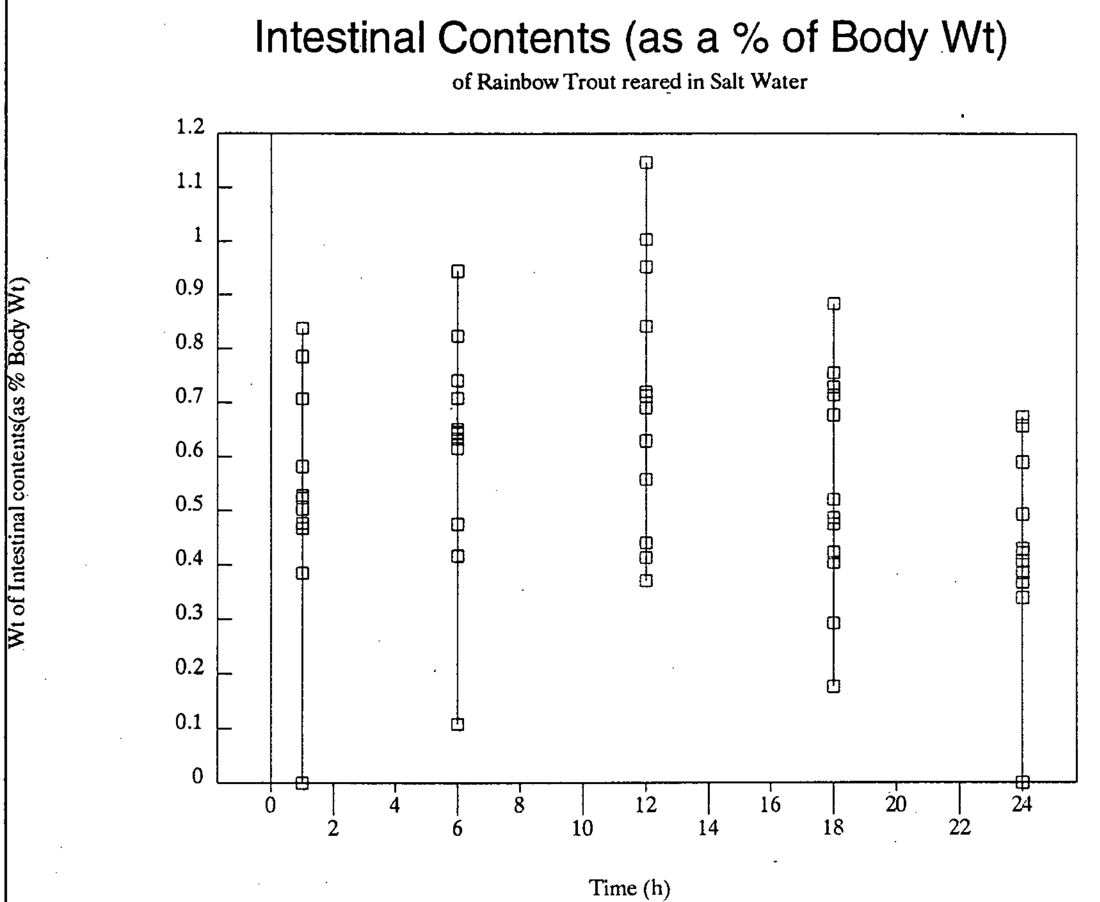
FIGURE 9C: Experiment 2: Stomach Contents Of Fish Reared on Diet 4 in Salt Water (Dry weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 4 = CELLULOSE/HIGH LIPID

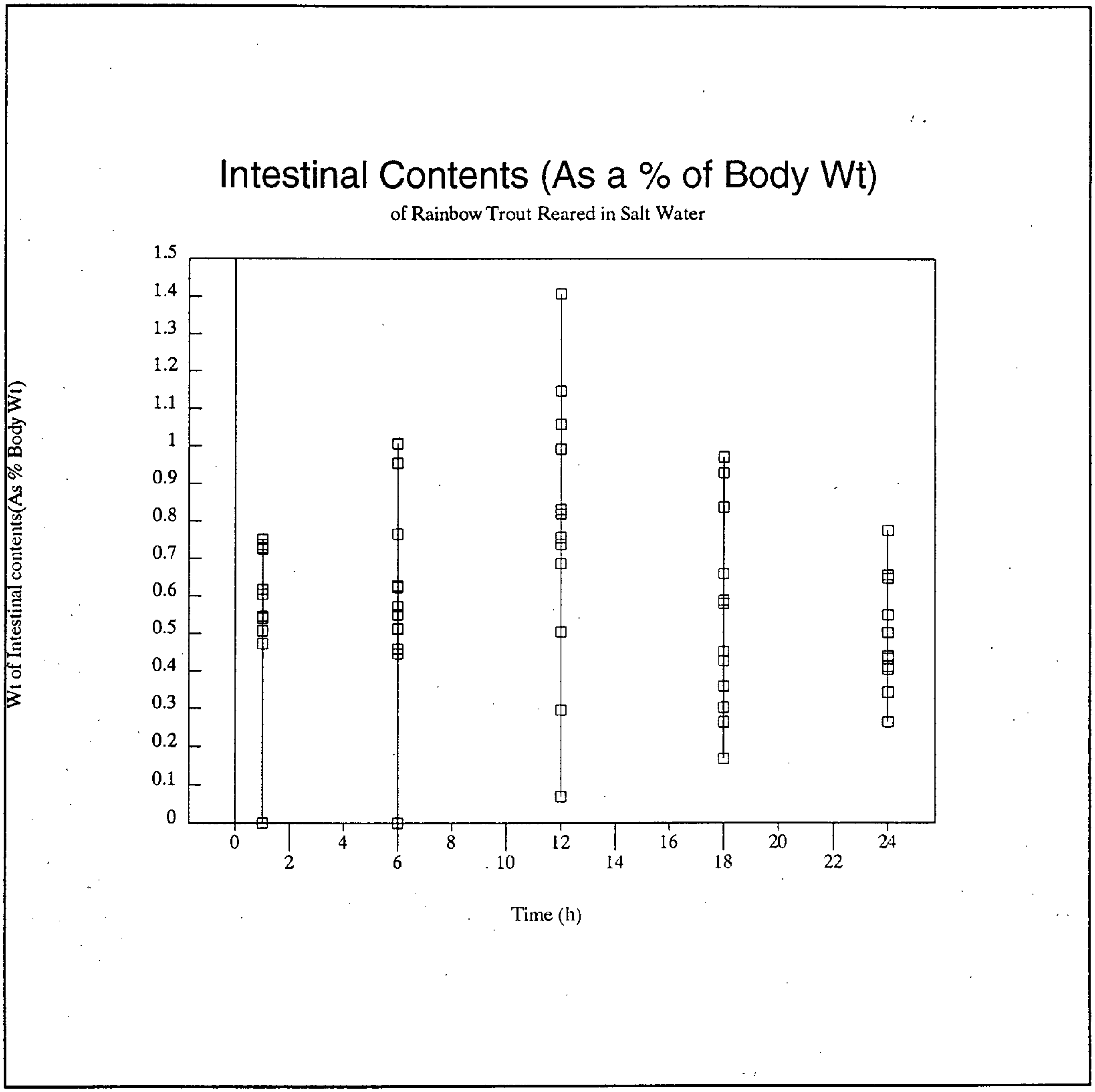
APPENDIX 10: Experiment 2: Intestinal Contents Of Rainbow Trout Reared in Salt Water.

FIGURE 10A: Experiment 2: Stomach Contents Of Fish Reared on Diet 1 in Salt Water (Dry weight (g) as % Body Weight).



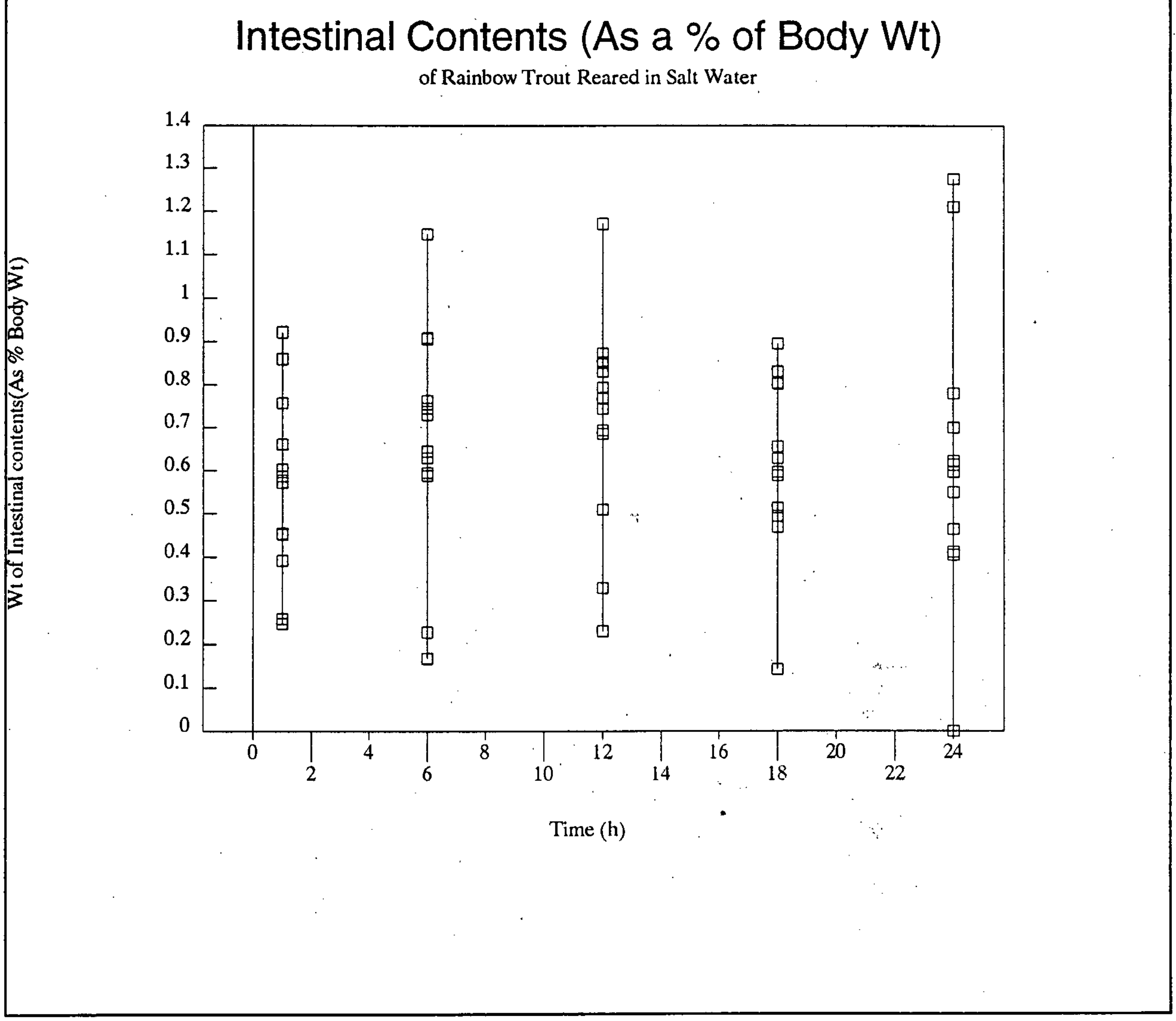
NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 1 = CONTROL DIET

FIGURE 10B: Experiment 2: Stomach Contents Of Fish Reared on Diet 3 in Salt Water (Dry weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 3 = HIGH LIPID

FIGURE 10C: Experiment 2: Stomach Contents Of Fish Reared on Diet 4 in Salt Water (Dry weight (g) as % Body Weight).



NB: EACH DATA POINT REPRESENTS 1 FISH
DIET 4 = CELLULOSE/HIGH LIPID

APPENDIX 11: Experiment 2, Salt Water, Statistical Results

ANOVA Results:

Stomach Contents

Time Period	Between Diets
1	P = 0.819
2	P = 0.096
3	P = 0.188
4	P = 0.641
5	P = 0.048*

TUKEY HSD MULTIPLE COMPARISON
Between Diets 3 and 4: P = 0.038

Intestinal Contents

Time Period	Between Diets
1	P = 0.675
2	P = 0.849
3	P = 0.800
4	P = 0.665
5	P = 0.015

TUKEY HSD MULTIPLE COMPARISON
Between Diets 1 and 4: P = 0.070
Between Diets 3 and 4: P = 0.018

To test for Tank Effects and ANOVA was done. Results were P= 0.2096

APPENDIX 12: EXPERIMENT 2, STOMACH AND INTESTINAL CONTENTS OF RAINBOW TROUT REARED IN SALT WATER

DIET	SAMPLING TIME (h)	TANK #	FISH WEIGHT (g)	DRY WT. STOMACH CONTENTS (g)	WET WT STOMACH CONTENTS (g)	DIFFERENCE WET WT VS DRY STM (g)	DIFFERENCE WET WT VS DRY STM (%BODY WT)	DIFFERENCE WET WT VS DRY INTESTINAL (g)	DIFFERENCE WET WT VS DRY INT (%BODY WT)	WET Wt INTESTINAL CONTENTS (g)	DRY WT. INTESTINAL CONTENTS (g)
	1	B	228	3.988	12.546	8.578	3.762	6.668	2.924	7.863	1.196
1		B	224	1.772	3.311	1.539	0.687	9.071	4.049	10.254	1.184
		D	243	3.679	11.099	7.420	3.054	6.990	2.876	8.124	1.135
CONTROL		D	303	2.750	10.114	7.364	2.430	7.777	2.567	9.302	1.524
		I	221	4.893	17.965	13.072	5.915	5.441	2.462	6.292	0.851
		I	241	4.107	15.426	11.319	4.696	9.274	3.848	10.980	1.706
		L	234	4.358	14.039	9.681	4.137	8.749	3.739	10.589	1.839
		L	170	0.000	1.764	1.764	1.038	3.791	2.230	3.791	0.000
		O	186	2.292	8.005	5.713	3.071	6.959	3.741	7.933	0.974
		O	207	2.482	8.546	6.065	2.930	5.589	2.700	6.577	0.988
		P	200	3.580	11.893	8.314	4.157	8.556	4.278	10.233	1.677
		P	182	3.485	10.790	7.304	4.013	5.086	2.794	6.146	1.060
		MEAN	220	3.397	10.458	7.344	3.324	6.996	3.184	8.174	1.285
		STD	34	0.916	4.447	3.236	1.411	1.684	0.669	2.104	0.325
		C	210	0.000	0.000	0.000		6.317	3.008	6.317	0.000
3		C	224	1.847	6.669	4.822	2.153	7.163	3.198	8.300	1.137
		G	199	4.360	13.308	8.948	4.497	6.470	3.251	7.699	1.229
HIGH		G	240	2.417	8.257	5.840	2.433	8.497	3.540	9.632	1.135
OIL		J	144	0.000	0.000	0.000		3.524	2.447	3.524	
		J	255	3.421	10.140	6.719	2.635	10.347	4.057	12.264	1.918
		M	197	0.871	5.256	4.385	2.226	7.179	3.644	8.256	1.076
		M	211	1.796	5.430	3.634	1.722	6.389	3.028	7.532	1.142
		Q	238	4.732	12.528	7.796	3.276	9.159	3.848	10.883	1.725
		Q	201	4.675	14.266	9.592	4.772	7.167	3.566	8.634	1.467
		R	176	3.818	11.635	7.817	4.441	7.701	4.376	8.998	1.297
		R	261	4.178	13.092	8.914	3.415	8.310	3.184	9.890	1.580
		MEAN	213	3.211	8.382	5.706	3.157	7.352	3.429	8.494	1.371
		STD	32	1.307	4.777	3.132	1.042	1.636	0.499	2.132	0.274
		A	289	4.581	14.232	9.650	3.339	7.525	2.604	9.266	1.741
		A	202	4.500	15.965	11.464	5.675	6.813	3.274	7.799	1.185
4		E	261	2.771	8.859	6.088	2.333	9.180	3.517	11.154	1.974
		E	212	2.156	7.513	5.357	2.527	6.090	2.873	7.302	1.212
ALPHA-		F	255	4.869	15.880	11.011	4.318	8.042	3.154	9.195	1.152
CELL		F	312	4.524	12.457	7.933	2.543	11.365	3.643	14.047	2.682
		H	195	2.077	7.140	5.063	2.597	4.512	2.314	4.991	0.479
		H	220	1.784	6.854	5.070	2.305	8.835	4.016	10.288	1.453
		K	166	0.402	3.288	2.886	1.738	5.294	3.189	5.944	0.650
		K	159	3.420	10.072	6.651	4.183	4.272	2.687	4.993	0.722
		N	138	1.193	5.335	4.142	3.001	3.956	2.867	4.311	0.356
		N	282	6.080	17.986	11.906	4.222	10.870	3.855	13.467	2.596
		MEAN	224	3.197	10.465	7.268	3.232	7.213	3.166	8.563	1.350
		STD	53	1.655	4.543	2.935	1.095	2.411	0.501	3.127	0.742

APPENDIX 12: EXPERIMENT 2, STOMACH AND INTESTINAL CONTENTS OF RAINBOW TROUT REARED IN SALT WATER

DIET	SAMPLING TIME (h)	TANK #	FISH WEIGHT (g)	DRY WT. STOMACH CONTENTS (g)	WET WT STOMACH CONTENTS (g)	DIFFERENCE WET WT VS DRY STM (g)	DIFFERENCE WET WT VS DRY STM (%BODY WT)	DIFFERENCE WET WT VS DRY INTESTINAL (g)	DIFFERENCE WET WT VS DRY INT (%BODY WT)	WET Wt INTESTINAL CONTENTS (g)	DRY WT. INTESTINAL CONTENTS (g)
1	6	B	230	0.253	12.696	12.443	5.410	10.297	4.477	10.547	0.250
		B	231	3.285	11.420	8.134	3.521	9.560	4.138	11.046	1.486
		D	249	2.024	11.185	9.161	3.679	8.359	3.357	9.936	1.577
CONTROL		D	208	2.227	9.005	6.778	3.259	6.547	3.148	7.535	0.988
		I	212	2.919	11.399	8.480	4.000	5.326	2.512	6.211	0.885
		I	276	1.848	8.248	6.399	2.319	9.129	3.308	10.828	1.699
		L	275	1.425	7.055	5.631	2.047	9.109	3.312	10.884	1.775
		L	242	1.577	8.331	6.754	2.791	9.270	3.830	11.064	1.794
		O	185	1.745	9.252	7.507	4.058	4.492	2.428	6.237	1.745
		O	243	3.577	12.911	9.334	3.841	8.983	3.697	10.985	2.002
		P	196	1.877	7.078	5.201	2.654	6.914	3.528	8.190	1.276
		P	224	3.684	13.559	9.875	4.409	7.972	3.559	9.559	1.587
		MEAN	231	2.203	10.178	7.975	3.499	7.996	3.441	9.418	1.422
		STD	27	0.959	2.199	1.956	0.911	1.724	0.564	1.802	0.475
		C	224	3.430	12.696	9.266	4.137	9.150	4.085	10.547	1.397
3		C	240	3.123	11.420	8.297	3.457	9.207	3.836	11.046	1.839
		G	163	3.306	12.511	9.205	5.647	4.638	2.844	5.386	0.750
HIGH		G	182	0.981	4.077	3.096	1.701	3.912	2.149	4.847	0.935
OIL		J	195	0.897	4.013	3.116	1.598	5.734	2.941	6.732	0.998
		J	195	3.149	11.017	7.868	4.035	5.935	3.043	7.009	1.075
		M	233	2.842	11.562	8.720	3.742	11.499	4.935	13.843	2.344
		M	232	1.618	7.460	5.842	2.518	9.846	4.244	12.062	2.216
		Q	196	4.285	15.247	10.962	5.593	6.565	3.349	7.795	1.230
		Q	136	0.000	0.000	0.000	0.000	2.698	1.984	2.698	0.000
		R	207	4.711	12.557	7.846	3.790	4.968	2.400	6.152	1.184
		R	214	3.877	15.351	11.474	5.362	6.317	2.952	7.271	0.954
		MEAN	201	2.929	9.826	7.141	3.465	6.708	3.230	7.949	1.357
		STD	29	1.208	4.644	3.320	1.667	2.549	0.856	3.134	0.514
		A	230	3.239	11.708	8.469	3.682	6.354	2.763	8.031	1.677
		A	231	3.901	14.660	10.759	4.658	7.242	3.135	8.696	1.453
4		E	190	1.694	10.018	8.324	4.381	5.170	2.721	7.349	2.179
		E	245	1.672	6.813	5.141	2.098	6.559	2.677	8.138	1.580
ALPHA-		F	222	2.215	13.404	11.190	5.040	8.644	3.894	10.656	2.011
CELL		F	198	3.692	12.824	9.132	4.612	5.482	2.768	6.644	1.163
		H	170	0.680	3.760	3.080	1.812	3.377	1.987	3.762	0.385
		H	209	1.198	6.294	5.096	2.438	8.587	4.108	10.180	1.594
		K	230	2.299	8.967	6.669	2.899	10.371	4.509	12.460	2.089
		K	258	3.793	13.485	9.692	3.757	7.255	2.812	9.177	1.922
		N	222	1.635	10.839	9.204	4.146	7.346	3.309	8.668	1.322
		N	169	0.070	1.716	1.646	0.974	2.640	1.562	2.923	0.283
		MEAN	215	2.174	9.541	7.367	3.375	6.586	3.020	8.057	1.471
		STD	27	1.206	3.948	2.913	1.250	2.105	0.808	2.582	0.589

APPENDIX 12: EXPERIMENT 2, STOMACH AND INTESTINAL CONTENTS OF RAINBOW TROUT REARED IN SALT WATER

DIET	SAMPLING TIME (h)	TANK #	FISH WEIGHT (g)	DRY WT. STOMACH CONTENTS (g)	WET WT STOMACH CONTENTS (g)	DIFFERENCE WET WT VS DRY STM (g)	DIFFERENCE WET WT VS DRY STM (%BODY WT)	DIFFERENCE WET WT VS DRY INTESTINAL (g)	DIFFERENCE WET WT VS DRY INT (%BODY WT)	WET Wt INTESTINAL CONTENTS (g)	DRY WT. INTESTINAL CONTENTS (g)
DIET	12	B	182	1.104	5.719	4.615	2.536	8.147	4.476	9.972	1.825
1		B	211	0.363	3.003	2.640	1.251	6.175	2.927	7.353	1.178
		D	290	1.748	8.769	7.021	2.421	10.325	3.560	12.150	1.825
CONTROL		D	224	1.465	6.281	4.816	2.150	7.977	3.561	9.523	1.546
		I	232	1.938	9.233	7.295	3.144	10.681	4.604	12.888	2.206
		I	207	3.070	12.132	9.062	4.378	8.464	4.089	9.939	1.475
		L	199	1.086	5.143	4.056	2.038	8.495	4.269	10.171	1.676
		L	196	2.411	10.588	8.176	4.172	5.022	2.562	5.832	0.810
		O	167	0.858	6.193	5.335	3.194	5.238	3.136	5.858	0.620
		O	190	2.776	11.512	8.736	4.598	6.231	3.279	7.067	0.836
		P	242	2.506	10.407	7.901	3.265	10.326	4.267	13.097	2.771
		P	200	1.825	7.014	5.189	2.595	8.392	4.196	9.834	1.442
		MEAN	212	1.762	7.999	6.237	2.978	7.956	3.744	9.474	1.518
		STD	31	0.791	2.732	1.974	0.973	1.861	0.637	2.409	0.588
		C	222	0.580	4.318	3.738	1.684	7.228	3.256	8.755	1.527
3		C	197	1.101	5.472	4.371	2.219	7.875	3.998	9.367	1.491
		G	144	0.000	0.000	0.000	0.000	2.622	1.821	2.722	0.100
HIGH		G	259	3.510	13.783	10.273	3.966	2.928	1.131	5.081	2.153
OIL		J	272	2.982	12.188	9.205	3.384	10.568	3.885	12.798	2.230
		J	182	1.814	8.474	6.660	3.660	8.179	4.494	9.985	1.805
		M	219	3.590	14.333	10.743	4.905	9.230	4.214	11.743	2.514
		M	210	0.054	2.997	2.943	1.401	5.513	2.625	6.136	0.623
		Q	170	1.961	7.622	5.662	3.330	6.102	3.589	7.357	1.255
		Q	202	2.190	9.358	7.168	3.548	7.479	3.703	8.499	1.020
		R	165	0.710	4.623	3.913	2.372	14.056	8.519	16.378	2.321
		R	214	2.481	13.252	10.770	5.033	10.932	5.108	13.195	2.264
		MEAN	205	1.907	8.035	6.287	2.959	7.726	3.862	9.335	1.609
		STD	36	1.138	4.484	3.319	1.413	3.134	1.766	3.648	0.720
		A	245	1.408	11.310	9.902	4.042	9.500	3.878	10.747	1.247
DIET		A	195	0.904	6.426	5.522	2.832	6.695	3.433	7.141	0.446
4		E	194	0.307	2.502	2.195	1.131	5.187	2.674	5.823	0.637
		E	202	0.861	5.563	4.702	2.328	7.375	3.651	8.976	1.601
ALPHA-		F	333	2.843	14.787	11.944	3.587	16.105	4.836	20.005	3.899
CELL		F	209	0.526	8.132	7.606	3.639	8.599	4.114	10.206	1.607
		H	280	0.620	7.326	6.706	2.395	2.789	0.996	5.111	2.321
		H	270	1.797	10.301	8.504	3.150	10.819	4.007	12.694	1.874
		K	233	1.871	9.377	7.505	3.221	8.265	3.547	10.295	2.031
		K	212	0.209	2.452	2.244	1.058	8.574	4.044	10.150	1.577
		N	300	1.752	14.403	12.650	4.217	10.903	3.634	12.960	2.057
		N	195	2.592	14.883	12.291	6.303	7.855	4.028	9.515	1.660
		MEAN	239	1.307	8.955	7.648	3.159	8.556	3.570	10.302	1.746
		STD	45	0.838	4.198	3.463	1.357	3.143	0.916	3.725	0.837

APPENDIX 12: EXPERIMENT 2, STOMACH AND INTESTINAL CONTENTS OF RAINBOW TROUT REARED IN SALT WATER

DIET	SAMPLING TIME (h)	TANK #	FISH WEIGHT (g)	DRY WT. STOMACH CONTENTS (g)	WET WT STOMACH CONTENTS (g)	DIFFERENCE WET WT VS DRY STM (g)	DIFFERENCE WET WT VS DRY STM (%BODY WT)	DIFFERENCE WET WT VS DRY INTESTINAL (g)	DIFFERENCE WET WT VS DRY INT (%BODY WT)	WET Wt INTESTINAL CONTENTS (g)	DRY WT. INTESTINAL CONTENTS (g)
DIET	18	B	290	1.878	14.625	12.747	4.396	11.306	3.898	13.376	2.070
1		B	139	0.205	2.169	1.964	1.413	3.520	2.532	3.765	0.245
		D	260	2.508	4.039	1.531	0.589	1.566	0.602	2.617	1.051
CONTROL		D	209	1.290	2.796	1.506	0.721	1.554	0.744	2.967	1.413
		I	217	1.691	7.528	5.837	2.690	5.582	2.572	6.216	0.634
		I	233	0.779	7.319	6.540	2.807	8.375	3.594	9.481	1.106
		L	221	2.429	12.422	9.993	4.522	9.635	4.360	11.587	1.952
		L	172	1.709	16.063	14.354	8.345	5.944	3.456	6.781	0.837
		O	158	0.542	4.046	3.504	2.218	5.482	3.469	6.303	0.822
		O	222	1.632	10.169	8.537	3.845	8.087	3.643	9.762	1.875
		P	215	1.554	5.327	3.773	1.755	5.224	2.430	6.790	1.566
		P	196	0.867	7.408	6.542	3.338	8.734	4.456	9.562	0.827
		MEAN	211	1.424	7.826	6.402	3.053	6.251	2.980	7.434	1.183
		STD	40	0.684	4.410	4.123	2.030	2.954	1.209	3.252	0.532
		C	201	1.885	7.839	6.154	3.062	9.266	4.610	11.218	1.951
3		C	195	1.733	6.843	5.110	2.620	6.881	3.529	8.013	1.132
		G	210	2.983	11.809	8.826	4.203	9.508	4.528	11.265	1.756
HIGH		G	179	1.511	7.882	6.370	3.559	7.743	4.326	9.405	1.662
OIL		J	186	0.724	4.090	3.366	1.810	4.876	2.622	5.717	0.841
		J	179	0.331	2.852	2.520	1.408	5.350	2.989	5.891	0.541
		M	245	0.365	3.664	3.299	1.346	6.775	2.765	7.819	1.045
		M	162	0.062	2.338	2.276	1.405	3.358	2.073	3.630	0.272
		Q	255	0.376	4.573	4.197	1.646	11.449	4.490	12.952	1.503
		Q	155	0.177	2.340	2.163	1.395	3.935	2.539	4.494	0.558
		R	223	1.421	5.676	4.255	1.908	8.556	3.837	10.027	1.470
		R	198	0.588	4.809	4.221	2.132	4.809	2.429	5.333	0.524
		MEAN	199	0.996	5.393	4.396	2.208	6.876	3.395	7.980	1.105
		STD	29	0.838	2.682	1.881	0.911	2.394	0.895	2.884	0.537
		A	246	1.516	4.673	3.157	1.283	4.836	1.966	6.878	2.042
DIET		A	154	0.398	7.237	6.839	4.441	10.092	6.553	11.101	1.009
4		E	174	0.583	3.625	3.042	1.748	5.427	3.119	6.286	0.860
		E	180	0.499	3.215	2.716	1.509	6.199	3.444	7.257	1.058
ALPHA-		F	269	1.352	5.314	3.962	1.473	13.437	4.995	15.842	2.405
CELL		F	243	1.506	6.420	4.914	2.022	10.670	4.391	12.615	1.945
		H	223	0.987	6.154	5.167	2.317	7.278	3.264	8.608	1.330
		H	193	0.593	5.544	4.952	2.566	6.732	3.488	7.637	0.905
		K	184	0.541	2.444	1.903	1.034	6.891	3.745	7.155	0.264
		K	280	0.729	8.378	7.648	2.732	9.558	3.413	11.314	1.757
		N	257	3.740	15.103	11.362	4.421	12.144	4.725	14.205	2.061
		N	247	4.100	21.021	16.921	6.851	8.426	3.411	9.694	1.268
		MEAN	221	1.379	7.427	6.049	2.700	8.474	3.876	9.883	1.409
		STD	40	1.200	5.163	4.113	1.645	2.604	1.110	3.003	0.606

APPENDIX 12: EXPERIMENT 2, STOMACH AND INTESTINAL CONTENTS OF RAINBOW TROUT REARED IN SALT WATER

DIET	SAMPLING TIME (h)	TANK #	FISH WEIGHT (g)	DRY WT. STOMACH CONTENTS (g)	WET WT STOMACH CONTENTS (g)	DIFFERENCE WET WT VS DRY STM (g)	DIFFERENCE WET WT VS DRY STM (%BODY WT)	DIFFERENCE WET WT VS DRY INTESTINAL (g)	DIFFERENCE WET WT VS DRY INT (%BODY WT)	WET Wt INTESTINAL CONTENTS (g)	DRY WT. INTESTINAL CONTENTS (g)
DIET	24	B	275	0.796	3.000	2.204	0.802	6.939	2.523	8.000	1.061
1		B	153	0.202	1.000	0.798	0.522	2.438	1.593	3.000	0.562
		D	250	0.692	2.000	1.308	0.523	5.946	2.378	7.000	1.054
CONTROL		D	196	1.894	8.500	6.606	3.371	4.681	2.388	6.000	1.319
		D	220	2.667	8.500	5.833	2.651	6.055	2.752	7.500	1.445
		I	221	0.400	5.500	5.100	2.308	1.552	0.702	2.500	0.948
		I	224	0.680	3.000	2.320	1.036	5.180	2.312	6.500	1.321
		L	274	1.095	7.500	6.405	2.337	0.071	0.026	1.000	0.929
		L	130	0.097	1.000	0.903	0.695	0.000	0.000	0.000	0.000
		O	190	0.448	2.000	1.552	0.817	3.268	1.720	4.000	0.732
		O	282	1.959	10.000	8.041	2.851	7.611	2.699	9.000	1.390
		P	175	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
		P	240	1.024	4.500	3.476	1.448	5.024	2.093	6.000	0.976
		MEAN	218	0.996	4.346	3.427	1.489	3.751	1.630	4.654	0.978
		STD	46	0.756	3.207	2.551	1.037	2.605	1.029	2.977	0.390
		C	261	0.433	2.500	2.067	0.792	3.809	1.459	4.500	0.691
3		C	181	0.054	1.000	0.946	0.523	4.088	2.259	5.000	0.912
		G	169	0.842	3.000	2.158	1.277	2.803	1.658	3.500	0.698
HIGH		G	195	0.857	7.000	6.143	3.150	5.237	2.686	6.500	1.263
OIL		J	239	0.492	2.500	2.008	0.840	7.184	3.006	8.500	1.316
		J	234	0.256	1.000	0.744	0.318	4.971	2.124	6.000	1.030
		M	172	0.181	2.000	1.819	1.058	3.303	1.920	4.000	0.698
		Q	252	1.618	12.000	10.382	4.120	6.388	2.535	7.500	1.112
		Q	195	0.361	3.000	2.639	1.353	5.220	2.677	6.500	1.281
		Q	188	0.555	4.500	3.945	2.098	4.185	2.226	5.000	0.815
		R	203	0.541	3.000	2.460	1.212	6.427	3.166	8.000	1.573
		R	153	0.645	5.000	4.355	2.847	2.475	1.617	3.000	0.525
		MEAN	204	0.569	3.875	3.306	1.632	4.674	2.278	5.667	0.993
		STD	34	0.392	2.938	2.577	1.125	1.431	0.529	1.712	0.307
		A	199	1.654	7.000	5.346	2.686	5.279	2.653	6.500	1.221
		A	214	2.293	7.500	5.207	2.433	5.222	2.440	6.500	1.278
DIET		A	149		0.000	0.000				0.000	
4		E	220	1.330	4.500	3.170	1.441	5.595	2.543	6.500	0.905
		E	196	1.587	5.000	3.413	1.742	4.127	2.105	6.500	2.373
ALPHA-		F	218	1.581	10.500	8.919	4.091	7.804	3.580	9.500	1.696
CELL		F	183	0.000	0.000	0.000				0.000	2.335
		F	189	0.897	4.500	3.603	1.907	4.622	2.446	5.500	0.878
		H	192	0.299	2.500	2.201	1.146	4.721	2.459	5.500	0.779
		H	127		0.000	0.000				0.000	
		K	219	0.838	5.500	4.662	2.129	5.468	2.497	7.000	1.532
		K	200	0.873	5.500	4.627	2.314	5.755	2.877	7.000	1.245
		N	189		0.000	0.000				0.000	
		N	248	0.954	5.000	4.046	1.631	7.135	2.877	8.500	1.385
		MEAN	196	1.231	4.107	3.228	2.152	5.573	2.648	4.929	1.419
		STD	29	0.539	3.124	2.513	0.785	1.067	0.377	3.272	0.513

APPENDIX 13: MARINIL AND ANESTHETIC DOSAGE

MARANIL DOSAGE

150 L tanks

Dosage Desired = 0.25 ppm or .25 mg Maranil/L water
Add to tank prior to handling.

ANESTHETIC DOSAGE

10 gallon container

1 g MS222 to 1 g bicarbonate of soda (buffer)

Mix into 10 gallon container of water.
Hold fish in container until they are immobilized sufficiently